Marks

Production control procedure for possible
use in Naval Shore Establishments based upon
a study of the production control.

Thesis
M345

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A PRODUCTION CONTROL PROCEDURE FOR POSSIBLE USE IN NAVAL SHORE ESTABLISHMENTS BASED UPON A STUDY OF THE PRODUCTION CONTROL DIVISION AT THE NAVAL ORDNANCE PLANT INDIANAPOLIS

A Thesis

Submitted to the Faculty

of

Purdue University

by

David A. Marks

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science in Industrial Engineering

June, 1950

Thesis
M336

ACKNOWLEDGEMENT

The majority of the principles expounded herein have been the natural result of numerous conferences with people engaged in Production Control today integrated with the concepts of production control as taught in current academic courses. It is indeed proper that this acknowledgement be made to give credit, where appropriate, for the data obtained.

To Captain A. D. Blackledge, Commanding Officer, Naval Ordnance Plant, Indianapolis; to Mr. D. D. Dennis, Head of the Production Control Division; and to the staff of the Plant, whose sincere and extremely helpful cooperation greatly aided the investigation, the author wishes to express his deepest gratitude.

Profound appreciation is extended to Professor Halsey F. Owen, of the Industrial Engineering Department, Purdue University, for his excellent guidance throughout the study.

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ABSTRACT

The problem of this study is to recommend a production control procedure for possible use in various Naval Shore Establishments.

The data upon which the recommended procedure is based was gathered from the Production Control Division, Naval Ordnance Plant, Indianapolis, Indiana. The functions of the recommended production control procedure were drawn from the texts listed in the Bibliography.

With the exception of the major changes in the production control procedure necessitated by a variation in the type of manufacture, the production control procedure used by the Naval Ordnance Plant, Indianapolis, Indiana, may be adapted for use in various Naval Shore Establishments. The recommended production control procedure includes the functions of material control, routing, scheduling, dispatching, and the determination of labor requirements.

A PRODUCTION CONTROL PROCEDURE FOR POSSIBLE USE IN NAVAL SHORE ESTABLISHMENTS BASED UPON A STUDY OF THE PRODUCTION CONTROL DIVISION AT THE NAVAL ORDNANCE PLANT INDIANAPOLIS

INTRODUCTION

The problems that arise in the Production Control Division of A Naval Shore Establishment may be different, in many cases, from those that occur in the Production Control Division of civilian industrial plants. It is with these possible differences in mind that this study was undertaken. It is felt that there is a definite need for such a study in order to help the military establishments keep abreast of the latest developments in production control and in the management field. Another aspect of such a study is that it may help to bring about further economy which is mandatory on the part of the military in peace time. Another and by no means less important aspect of such a study is that it may provide a functional structure upon which an existing Production Control Division could be reorganized, or which could be used in the expansion program during a national emergency.

Previously accomplished work which is related to the problem was done by Lieutenant Colonel Robert W. Breaks, U.S.A., in his thesis, "An Appraisal of the Production Control Methods Used at Government Arsenals," June, 1947. This thesis dealt primarily with the production control methods applicable to chemical manufacturing processes.

The majority of the information upon which the present study is based was obtained at the Naval Ordnance Plant, Indianapolis, Indiana, which is sometimes abbreviated in this paper as NOPI. The information was obtained by means of conferences with each responsible individual in the Production Control Division. These conferences resulted in the

obtaining of forms and charts pertaining to a particular unit along with sufficient information about the functions of that unit to describe in general the unit's responsibilities and its place in the organizational structure of the production control division. Using this information as a basis for investigation, this study was compiled by considering the prime functions of each unit and how these functions would apply to the problems of the production control divisions of various Naval Shore Establishments.

Production Control may be defined as the mental and physical techniques applied in such a way that the right quantity and quality of a product will be produced at the right time by the best and cheapest methods. This definition appears widely in the literature on the subject of production control; its interpretation, however, has extremely broad scope. Based upon the collective opinion expressed in the first six texts in the Bibliography, the major emphasis placed on the interpretation of the definition of production control includes the functions of (1) material control, (2) routing, (3) scheduling, (4) dispatching, and (5) labor requirements.

THE NAVAL ORDNANCE PLANT, INDIANAPOLIS, INDIANA

The History, Organization, and Physical Properties of the U. S. Naval Ordnance Plant, Indianapolis, Indiana

This plant was designed, constructed, and staffed by a civilian engineering company during World War II for the purpose of manufacturing the Norden bombsight and related equipment, and aircraft lead-computing gunsight systems; some sixty thousand fire control instruments were manufactured during World War II.

Late in 1945, the plant was taken over by the Navy. It is now being run under the cognizance of the Bureau of Ordnance, Navy Department. As a Naval Shore Establishment, the plant has the following functions:

(1) research in, and engineering development of, aviation fire control equipment;

(2) the manufacture of that equipment;

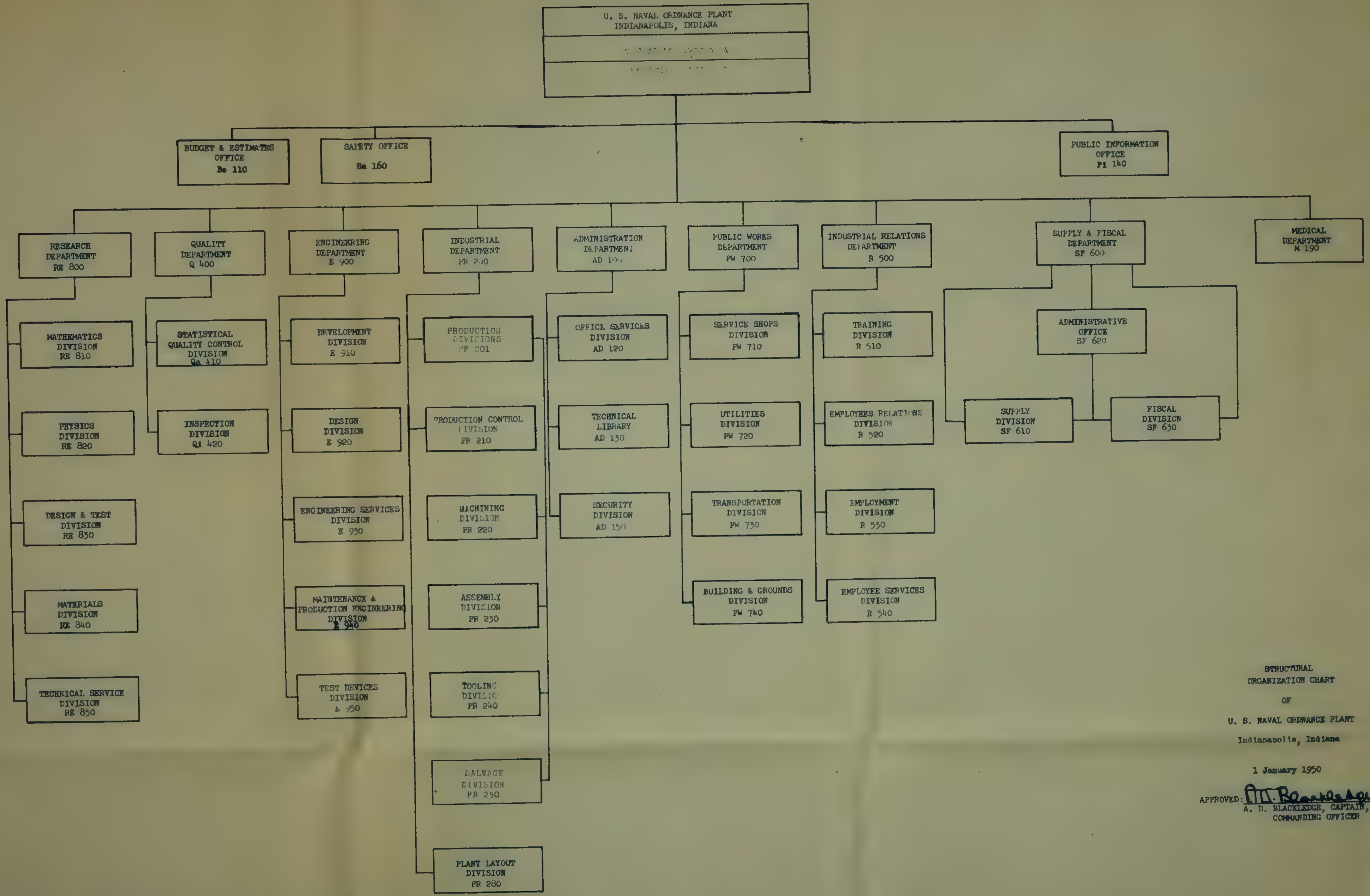
(3) the manufacture of line maintenance stores;

(4) the overhaul, modification, and modernization of fire control instruments, including radar attachments and their accessories.

The present staff of the plant consists of the original employees who were inducted into the Civil Service system at the time of conversion to naval control. Assigned to the plant are 11 naval officers and 5 enlisted men, and 1 Marine officer and 40 enlisted men. These officers and men serve in the following capacities at the plant: as Commanding Officer and Executive Officer, and in the Budget Office, the Security Division, the Safety Office, the Communications Office, the Supply and Fiscal Department, and the Medical Department.

Organized under the direction of the Commanding Officer with the assistance of the Executive Officer, the plant has nine departments. These departments are divided into divisions composed of sections, which are in turn subdivided into units. A structural organization chart of the plant at the divisional level appears in Figure 1.

Located in northeastern Indianapolis, Indiana, the plant occupies some one-hundred-sixty acres of land. Its main structure, the manufacturing building, is nine-hundred-twenty feet long and five-hundred-sixty feet wide, covering eleven and a half acres of floor space. The plant facilities are of the most modern type, including an air-conditioning system affording constant temperature and controlled humidity, with six complete changes of inside air cleaned through an electrostatic filter in one hour. Heat is supplied by two oil-burning steam boilers. The lighting system employs both direct and indirect facilities, and maintains a one-hundred foot candle intensity at the work stations. These modern facilities afford to the plant's staff the maximum in comfort and ideal working conditions.


U. S. NAVAL ORDNANCE PLANT
INDIANAPOLIS, INDIANA
BUDGET & ESTIMATES OFFICE Be 110
SAFETY OFFICE Sa 160
PUBLIC INFORMATION OFFICE Pi 140
RESEARCH DEPARTMENT RE 800
MATHEMATICS DIVISION RE 810
PHYSICS DIVISION RE 820
DESIGN & TEST DIVISION RE 830
MATERIALS DIVISION RE 840
TECHNICAL SERVICE DIVISION RE 850
QUALITY DEPARTMENT Q 400
STATISTICAL QUALITY CONTROL DIVISION Qa 410
INSPECTION DIVISION Qi 420
ENGINEERING DEPARTMENT E 900
DEVELOPMENT DIVISION E 910
DESIGN DIVISION E 920
ENGINEERING SERVICES DIVISION E 930
MAINTENANCE & PRODUCTION ENGINEERING DIVISION E 940
TEST DEVICES DIVISION E 950
INDUSTRIAL DEPARTMENT PR 200
PRODUCTION DIVISIONS PR 201
PRODUCTION CONTROL DIVISION PR 210
MACHINING DIVISION PR 220
ASSEMBLY DIVISION PR 230
TOOLING DIVISION PR 240
SALVAGE DIVISION PR 250
PLANT LAYOUT DIVISION PR 280
ADMINISTRATION DEPARTMENT AD 100
OFFICE SERVICES DIVISION AD 120
TECHNICAL LIBRARY AD 130
SECURITY DIVISION AD 150
PUBLIC WORKS DEPARTMENT PW 700
SERVICE SHOPS DIVISION PW 710
UTILITIES DIVISION PW 720
TRANSPORTATION DIVISION PW 730
BUILDING & GROUNDS DIVISION PW 740
INDUSTRIAL RELATIONS DEPARTMENT R 500
TRAINING DIVISION R 510
EMPLOYEES RELATIONS DIVISION R 520
EMPLOYMENT DIVISION R 530
EMPLOYEE SERVICES DIVISION R 540
SUPPLY & FISCAL DEPARTMENT SF 600
ADMINISTRATIVE OFFICE SF 620
SUPPLY DIVISION SF 610
FISCAL DIVISION SF 630
MEDICAL DEPARTMENT M 190

STRUCTURAL
ORGANIZATION CHART

OF

U. S. NAVAL ORDNANCE PLANT

Indianapolis, Indiana

1 January 1950

APPROVED: A. D. Blackledge
A. D. BLACKLEDGE, CAPTAIN, USN
COMMANDING OFFICER

The Nature of the Product

The product of the plant is aviation fire control systems, engineered and manufactured to meet service performance requirements and specifications. The mathematical expressions for the solution of various fire control situations are mechanized to a fine degree of accuracy. Mechanical and electronic methods translate the theoretical principles into useable systems.

A component unit of a fire control system is, in reality, a precision instrument. The exactness in the manufacture of a unit's individual parts is comparable to that employed by the most skilled toolmakers in industry.

There is a great variety of products among the aviation fire control systems. Thus, the system which is installed in a fighter to control the fire of its guns is vastly different from that installed in a high-altitude bomber to control the dropping of its bombs. The addition of controls for torpedoes, rockets, and air-launched guided missiles further increases the dissimilarity between the fire control systems.

The product of the plant is, therefore, precision instruments possessing little uniformity among themselves.

The Problem of Production Control

The plant is engaged in a combination of the job shop and intermittent types of manufacture. This type of manufacture is characterized by the production of special orders and of a great variety of products in limited quantities. In a year's time, the plant may receive three-hundred special orders which will require the production of one-hundred-thousand different items in average quantities of twenty-five units per item.

Some of the factors which necessitate a complex production control system are:

1. Number of ultimate parts in the product.
2. Number of different operations on each part.
3. Extent to which processes are dependent, i.e., those which cannot be performed until previous operations have been completed.
4. Variation in capacity of machines for different classes of work. In many industries speed of machines varies according to the nature of the material being worked on.
5. Degree to which subassembly exists.
6. Degree to which customers' orders with specific delivery dates occur.
7. Receipt of orders for many small lots.[1]

The fact that the product, aviation fire control equipment, is comprised of precision instruments having large variety among themselves accentuates the factors listed above.

The machine tools in the plant are of the general purpose type. On the whole, there is a surplus of machine tools. The special nature and complexity of the finished product necessitates the designing of special testing equipment. Normally, available commercial test equipment is modified to meet the plant's special needs. In some cases,

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[1] Alford, L. P., Bangs, John R., Production Handbook, The Ronald Press Company, New York, N. Y., 1944, pp. 75.

however, test equipment must be designed from basic fundamentals.

The employees in the Machining and Assembly Divisions are skilled craftsmen. Each machinist is capable of operating several types of machine tools. The Assembly Division employees are, in many cases, qualified machine operators; and the machinists, in turn, are capable of doing assembly work. Thus, when the plant is overloaded with machine tool work, the Assembly Division employees can be transferred to the Machining Division. The control of such inter-division personnel is a function of the Production Control Division.

To summarize, the nature of the product, the special equipment required in its manufacture, and the skilled staff of the plant present complex problems which must be solved by the Production Control Division.

The Production Control Division

The Organization of the Production Control Division.

The Production Control Division, one of six divisions comprising the Industrial Department, consists of three sections, the Planning, Methods, and Progress Sections. Each of these is divided into various units. The organization chart of the Industrial Department, including the unit breakdown, appears in Figure 2.

The Responsibilities of the Production Control Division.

The Production Control Division plans and directs the scheduling of production activities; provides materials, tools, and specific manufacturing instructions for the operating shops; maintains daily floor checks to eliminate delays and work stoppages; moves stores and disposes of all manufactured items; is the source of all data on production performance, current and anticipated plant productive load, estimated productive and non-productive expenditures, current budget status of productive projects and the Industrial Department's maintenance allocations; acts in an advisory capacity in the matter of employment level and confers with the Engineering Department in the matter of product design for economical manufacture.

The responsibilities of the sections of the Production Control Division are as follows:

The Planning Section is charged with the responsibility of both long range and specific project planning and scheduling; the ordering of raw materials and purchased parts; the issuance of shop order kits; the preparation of charts and graphs indicating production performance trends, and other statistical production data; the compilation and reporting of production costs to provide comparison between the

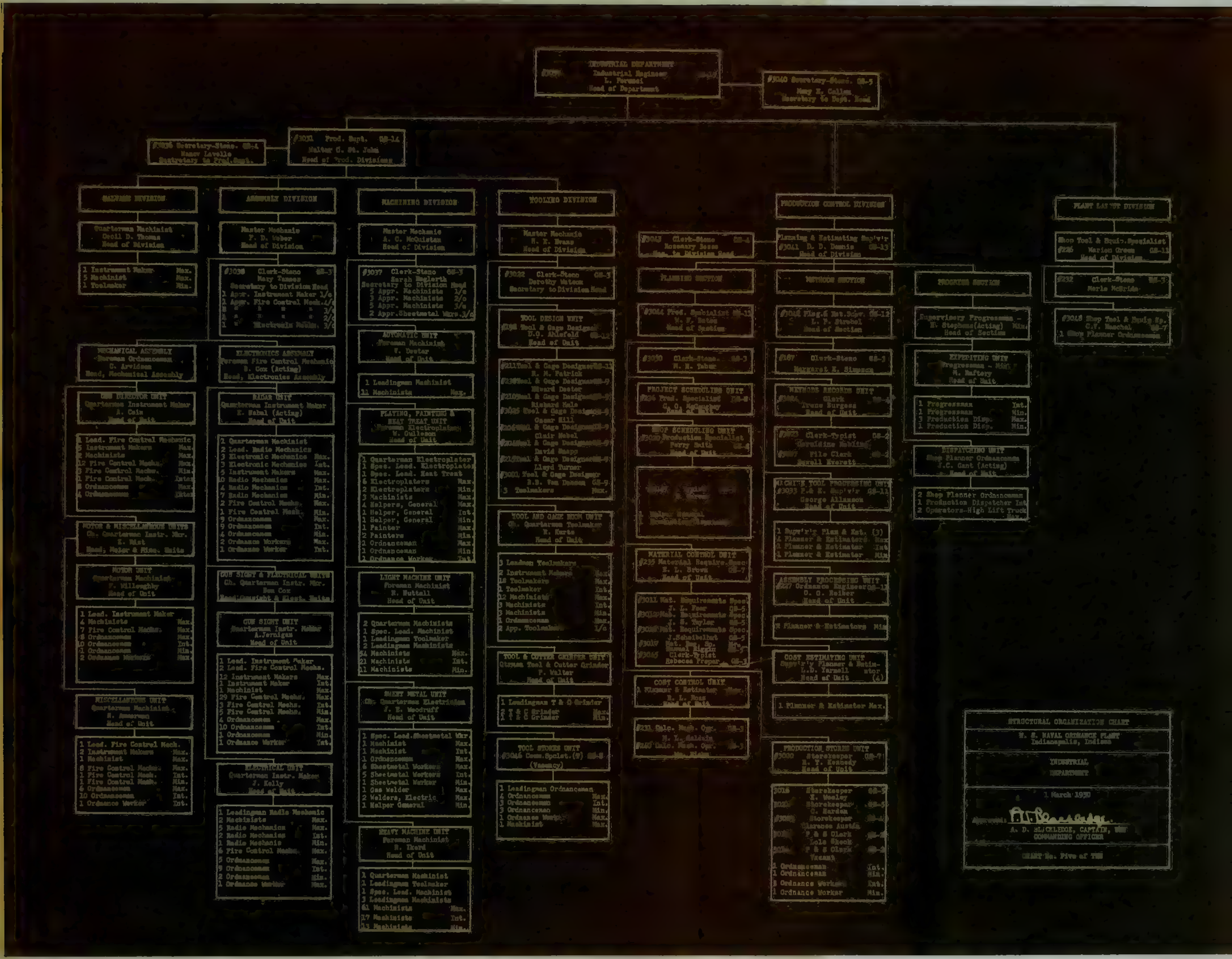


Fig. 2 Organization Chart of Industrial Department

original estimate and the actual expenditure; and the control of project expenditures.

The Methods Section is responsible for cost estimation for the proposed production work; the preparation of detailed process routing sheets (operation sheets) for component parts, sub-assemblies, finished units, and the necessary time to perform such operations; the ordering of all special tools and gages; the designing and ordering of special test equipment; conferring with the Engineering Department regarding changes of design which will facilitate production and lower costs; the receipt, recording, and distribution of engineering information to the Industrial Department; the advising of the Plant Layout Division regarding the placement of machine tool equipment; and the recommendation of procurement of specialized machine tool equipment and accessories.

The Progress Section is charged with the responsibility of distributing the shop order kits; insuring the completion of scheduled work on time; expediting the procurement of raw materials, tools, gages, and purchased parts; conferring with the various departments regarding solutions of production "bottlenecks;" reporting weekly the production status of projects; and the inter-divisional handling of materials.

The Handling of a Proposal

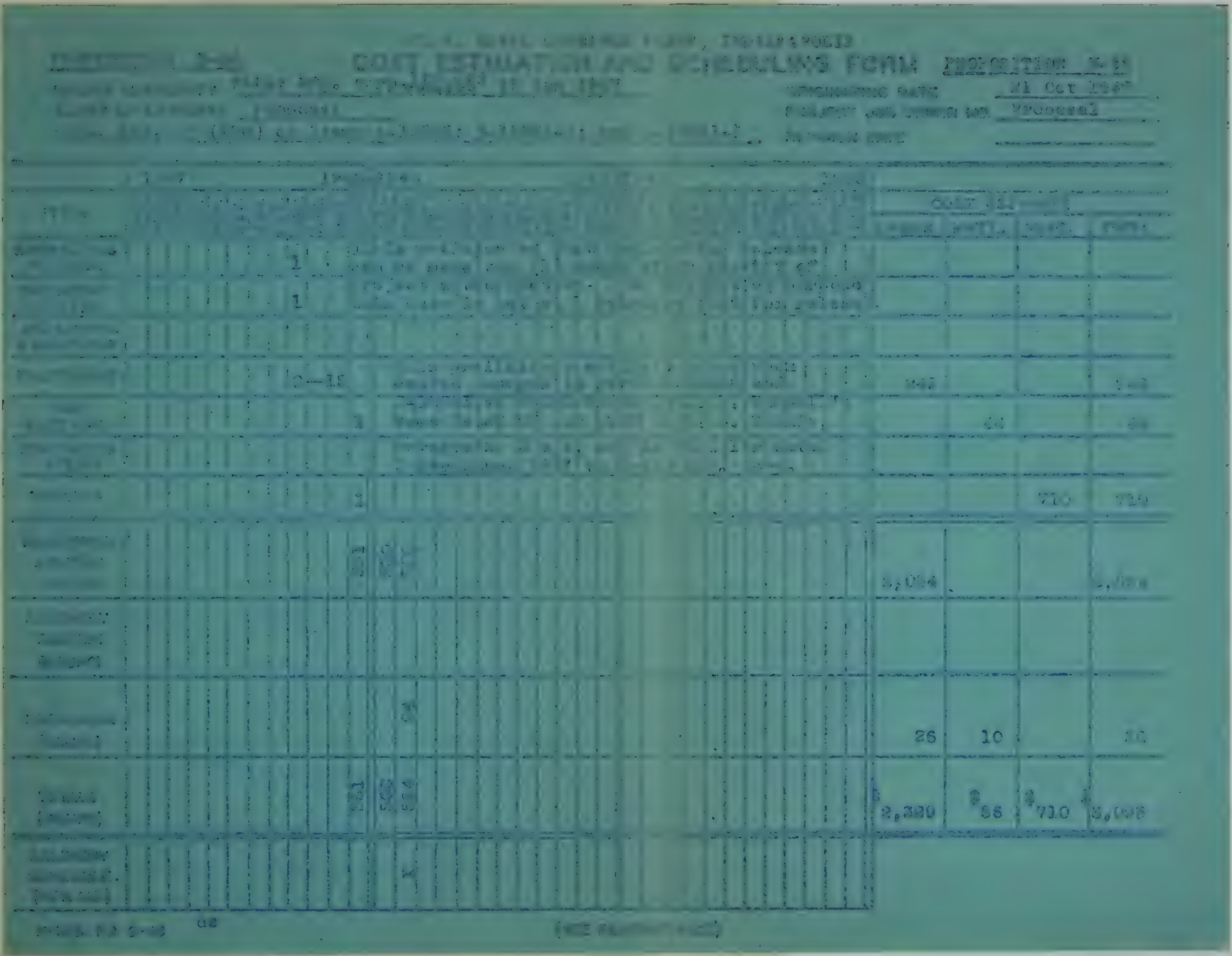
The Bureau of Ordnance, before allocating funds or authorizing a plant to begin work on a project, requires each plant interested in bidding on the work to submit an estimate or proposal as to the expected delivery date of the first completed item and the approximate cost of the project. Generally in letter form, the Bureau's request for this estimate is accompanied by rough prints and parts lists pertaining to the product, or by a word description of the product.

This letter is received and processed by the Budget Office of the plant administration. The Proposal or Cost Estimation and Scheduling Form (blue), Figure 3, is originated in that office and accompanies the prints to the Engineering Department, where they are examined for the purpose of estimating an engineering release date. This date is then entered on the proposal.

From the Engineering Department the proposal and attachments then go to the Cost Estimating Unit of the Production Control Department, where all the remaining estimates, with the exception of the delivery schedule, are made. The Cost Estimating Unit fills in the cost estimate columns of the proposal in terms of dollars only. The method used to arrive at these estimates will be described later in a section on this unit.

When the above cost estimation is complete, the proposal is then returned to the Project Scheduling Unit, where an estimate is made as to where in the work load the project can be placed, when delivery on the finished products can be expected, and in what quantity they can be completed during each period until the project's termination.

The proposal and its accompanying papers are then returned to



U. S. NAVAL ORDNANCE PLANT, INDIANAPOLIS

COST ESTIMATION AND SCHEDULING FORM

Fig. 3 Cost Estimation and Scheduling Form

the Budget Office for final review, issuance, and submission to the applicable activity.

These estimations and information are presented in general form and are regarded as a tentative commitment by the plant. They serve as a broad basis for planning by the Bureau of Ordnance, for cost estimation and approximate delivery schedules.

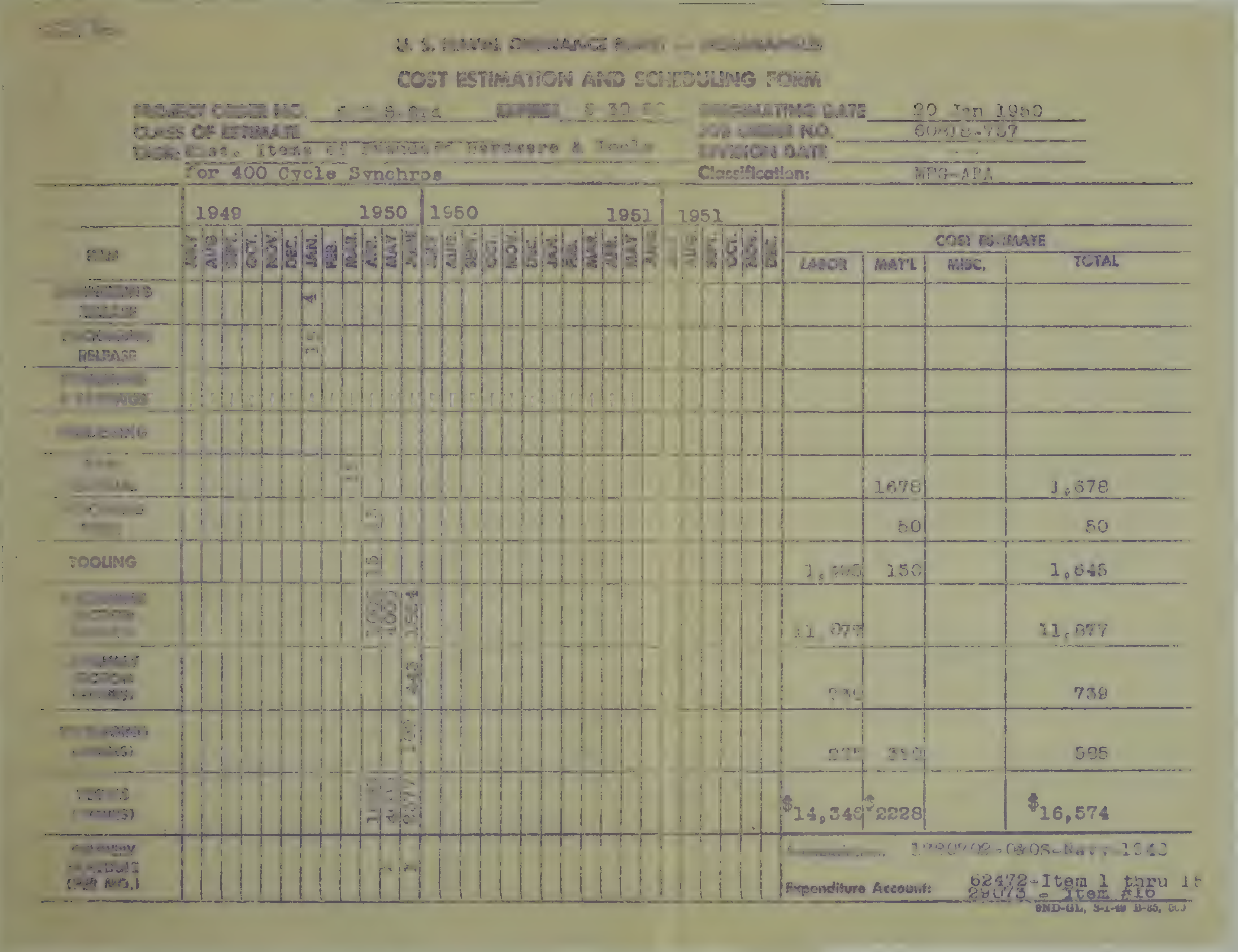
The Handling of a Firm Estimate

When the Bureau of Ordnance has decided to authorize the plant to begin work on a project and has allocated the necessary funds, this authority and allocation come to the plant in the form of a project order number and an allotment number. These are received by the Budget Office and are processed in the same manner as was the information pertaining to a proposal.

The Firm Estimate or the Cost Estimation and Scheduling Form (white), Figure 4, is originated by the Budget Office and differs from the proposal only in color and the amount of information thereon. This form and current pertinent information, which may include more detailed prints and, or parts lists, are forwarded to the Engineering Department. The Engineering Department proceeds as expeditiously as possible with the work of originating production engineering releases without awaiting a formal job order. This precludes delay of the engineering release because of delay in issuing a job order. If the firm estimate is accompanied by a word description only, the Engineering Department develops the prints and parts lists. A revised engineering release date is made in greater detail than in the case of the proposal.

The originated or revised prints and parts lists are sent to the Methods Records Unit, who transmits a copy to the Material Control Unit. The Material Control Unit uses the information from the parts lists to determine whether the parts can be obtained from the Supply system or whether they will have to be procured in another manner.

This information, together with the firm estimate, is then passed to the Cost Estimating Unit. Using the information furnished by Budget, Engineering, and Supply, and their own internal work forms, the



U. S. NAVAL ORDNANCE PLANT — INDIANAPOLIS

COST ESTIMATION AND SCHEDULING FORM

PROJECT ORDER NO. [illegible] EXPIRES 6-30-50 ORIGINATING DATE 20 Jan 1950
CLASS OF ESTIMATE JOB ORDER NO. 60818-757
DESCR. Est. Items of [illegible] Hardware & Tools REVISION DATE
for 400 Cycle Synchros Classification: MPG-APA

	1949											1950	1950											1951	1951						COST ESTIMATE			
[illegible]	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	LABOR	MAT'L	MISC.	TOTAL
[illegible]							4																											
[illegible] RELEASE							15																											
[illegible]																																		
[illegible]																																		
[illegible]									15																							1678		1,678
[illegible]										15																						50		50
TOOLING										15																					1,[illegible]	150		1,645
[illegible]										[illegible]	[illegible]	[illegible]																			11,877			11,877
[illegible]												[illegible]																			739			739
[illegible]												[illegible]																			275	320		595
[illegible]										[illegible]	[illegible]	[illegible]																			$14,349	$2228		$16,574
[illegible] (PER MO.)																																		

[illegible] [illegible]

Expenditure Account: 62472-Item 1 thru 15
29073 - Item #16

9ND-GL, 3-1-49 B-85, 600

Fig. 4 Cost Estimation and Scheduling Form

Cost Estimating Unit makes an accurate estimate of the costs that will be incurred in the process of manufacturing a complete project. This estimate is made as a result of more meticulous investigation than was afforded the proposal.

The Firm Estimate is then returned to the Project Scheduling Unit for processing similar, with a few exceptions, to that given the proposal. As well as estimating the delivery schedule, this unit breaks down each cost figure into man-hours and loads the firm order by months. Consideration is given to the total available man-hour capacity of the plant and to the already existing load when the loading of a new project is undertaken.

The completed Firm Estimate is then returned to the Budget Office for final review, issuance, and submission to the applicable activity.

As was noted in this discussion, the estimates and information presented are the result of extended investigation and are considered a definite commitment by the plant, since they are specific information pertaining to the Bureau's planning regarding costs and scheduled delivery dates.

The firm Cost Estimation and Scheduling Form for a project actuates the flow of work in the Production Control Division. There is a great exchange of information between units which, if included in a general flow diagram, would become confusing, defeating the diagram's general purpose of giving an over-all picture of the work flow in the Production Control Division. Only the general pattern of the work flow is indicated and only the more important forms mentioned in the description of the functions of the various units. The following diagram shows

The Project Scheduling Unit

The Project Scheduling Unit plans the over-all plant schedule, issues the internal scheduling for the Production Divisions, and compiles certain important production statistics which aid in formulating the plant's labor requirements.

The following forms are originated in the Project Scheduling Unit: The Internal Schedule Form, shown in Figure 5, indicates the required completion dates of a project. The information contained in this form is taken from the Cost Estimation and Scheduling Form, and is distributed throughout the plant. Each division advises the Unit as it completes its portion of the project, thus furnishing the Unit with an accurate record of the status of each project.

The Forecast of Productive Labor, Figure 6, is a chart which displays the over-all plant production forecast in terms of man-hours, projected eighteen months ahead. The data is divided into program numbers, and represents the load on the various departments. The main function of this chart is to determine the amount of new work which can be undertaken by the plant in the near future. The chart is sent to the Bureau of Ordnance via the plant administration.

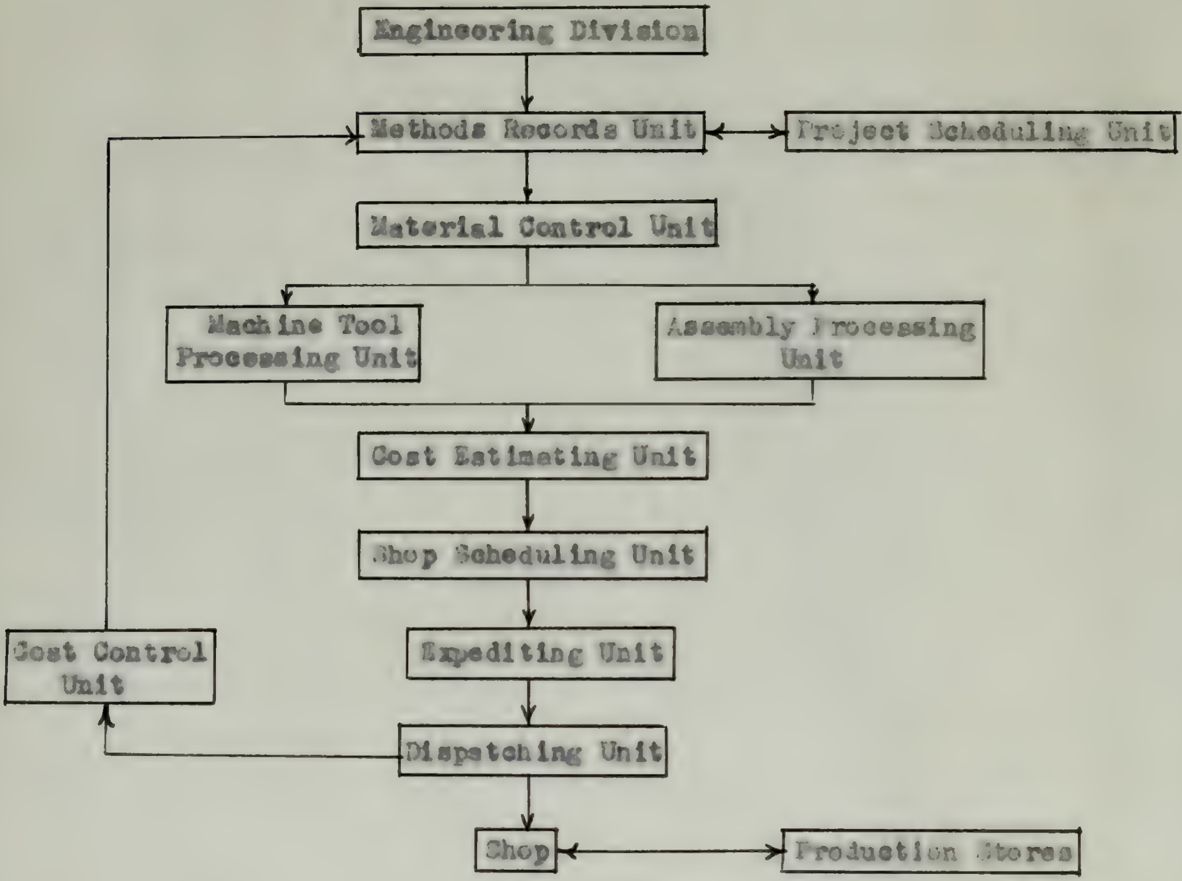
The Load and Performance Chart, shown in Figure 7, represents the efficiency of the shop relative to the time estimates of the Cost Estimating Unit. This chart serves as an efficiency standard for the shop, showing the amount of work completed by the shop against the amount of work released to the shop by the Production Control Division. Sources of the chart's information are the Weekly Machine Load Report and the Fiscal Labor Report.

The Monthly Man Load Summary is in the form of a letter stating

the general flow of work between the Units of the Production Control Division.

General Work Flow Diagram

Production Control Division

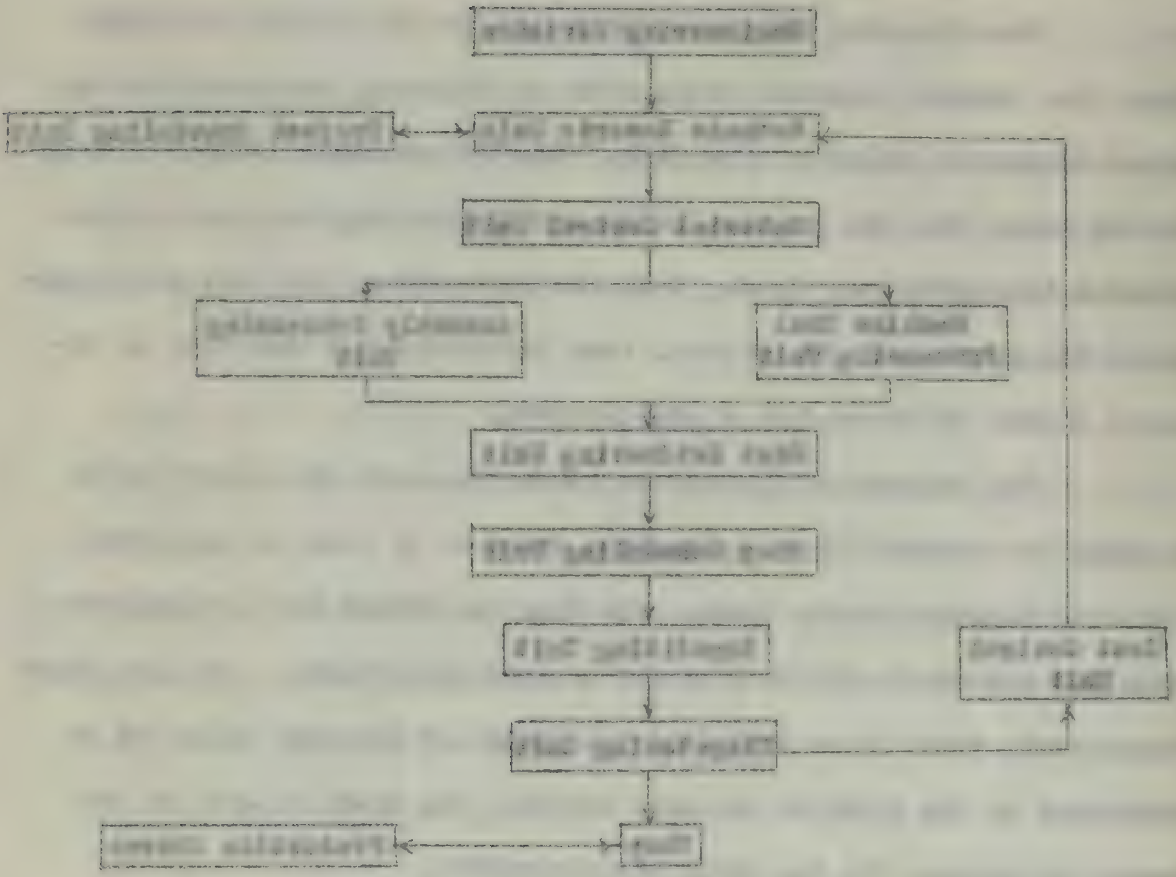


The functions of the various units are described on the following pages.

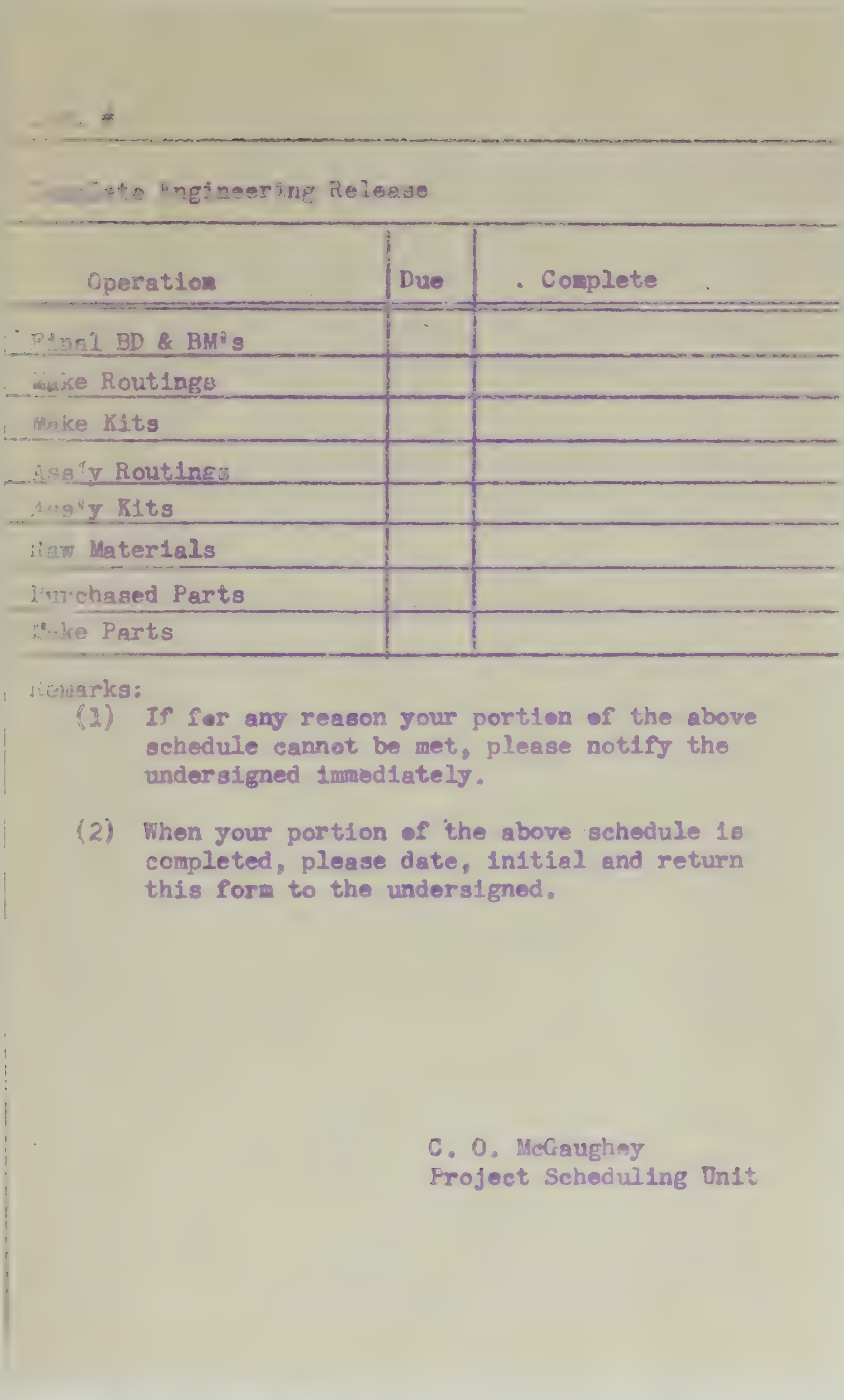
the general flow of work between the units of the Production Control Division.

General Work Flow Diagram

Production Control Division



The functions of the various units are described on the following pages.



#

Complete Engineering Release

Operation	Due	Complete
Final BD & BM's		
Make Routings		
Make Kits		
Ass'y Routings		
Ass'y Kits		
Raw Materials		
Purchased Parts		
Make Parts		

Remarks:

(1) If for any reason your portion of the above schedule cannot be met, please notify the undersigned immediately.

(2) When your portion of the above schedule is completed, please date, initial and return this form to the undersigned.

C. O. McGaughey
Project Scheduling Unit

Fig. 5 Internal Schedule

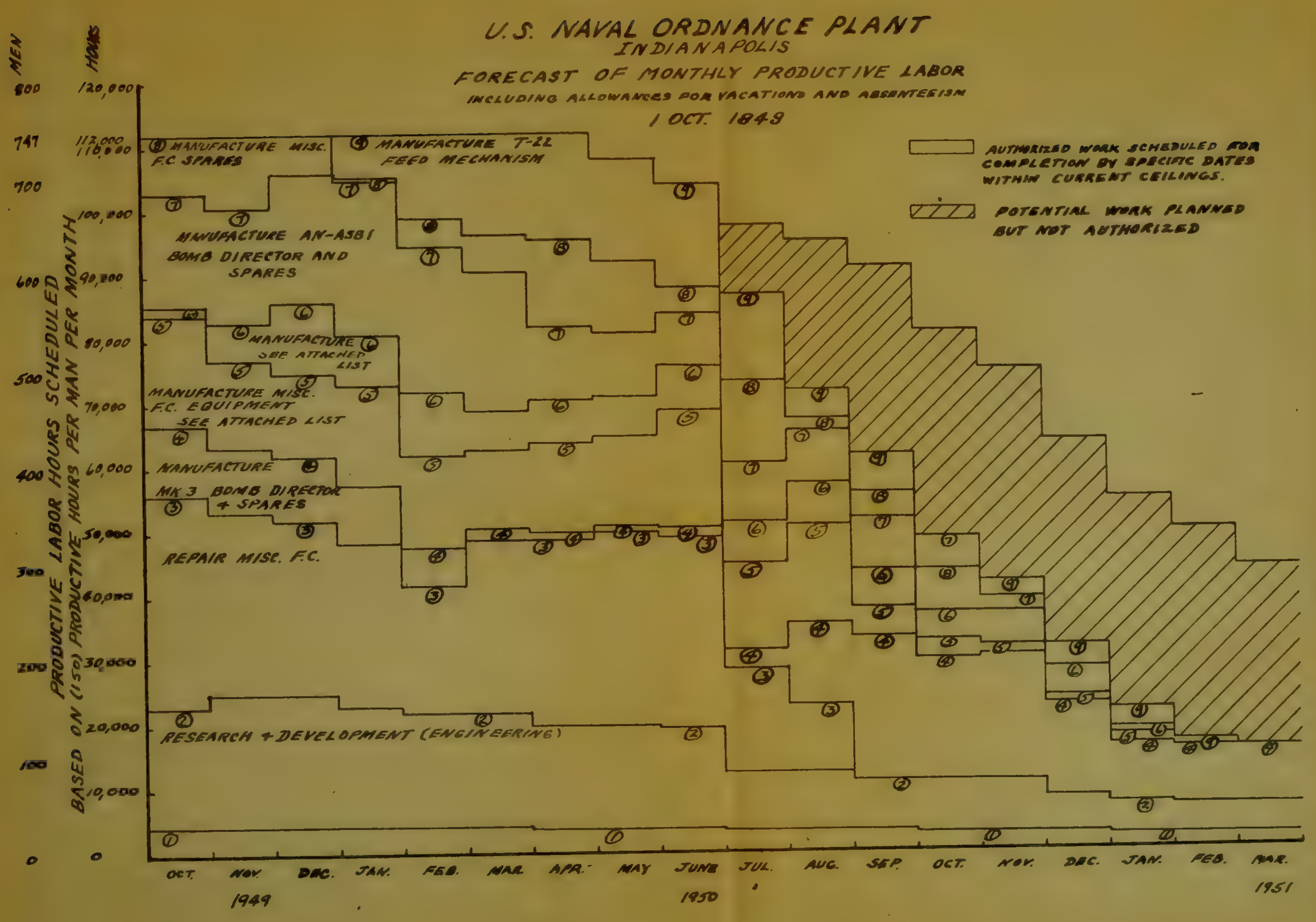


Fig. 6 Forecast of Productive Labor Chart

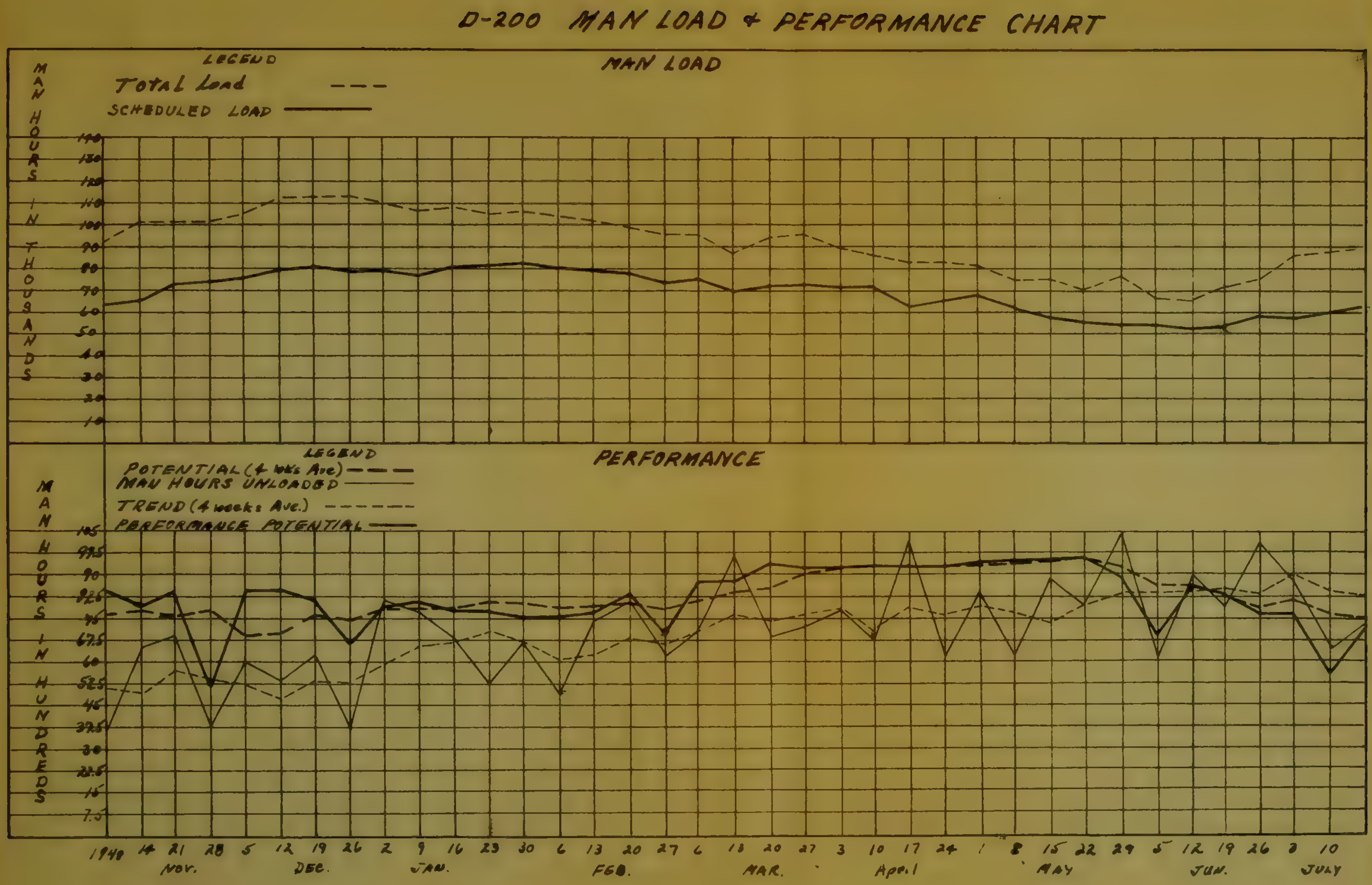
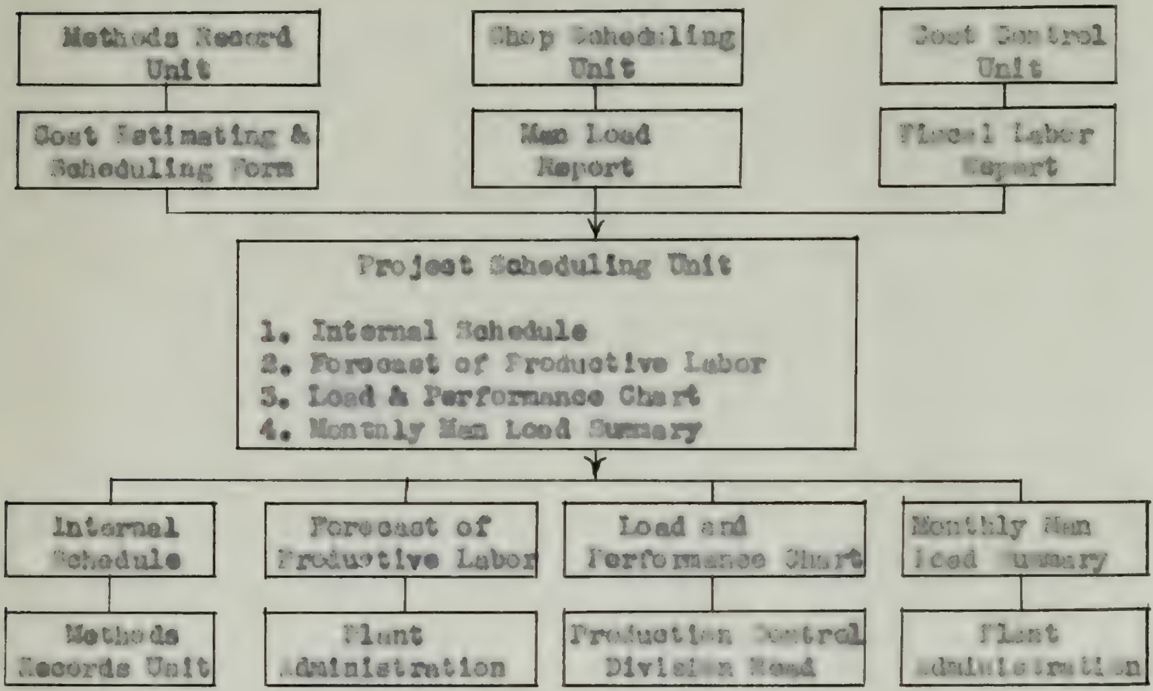


Fig. 7 Load and Performance Chart

the man-hours of machinery, assembly, and tooling completed in a month. Based on the Forecast of Productive Labor, this summary recommends transfers of labor between divisions and the adjustment of the labor force to meet the production requirements of the immediate future. It also contains a brief account of the status of all projects, a report on the important occurrences in and outside of the plant during the past month (such as a national coal strike), and their effect on the progress of the plant's various projects. This summary is used for administrative guidance.

The flow of information into the Unit, the forms originated therein, and their destination are shown in the diagram below.



The Methods Records Unit

The Methods Records Unit is responsible for receipt, stowage, and distribution of Engineering data and for keeping the many files up to date. These files contain a variety of items, such as job orders, blueprints, parts lists, production breakdown sheets, and many others. One of the other responsibilities of the Unit is to act as a collecting agency in making up the "folders" that are originated to implement the production of a new part. It is obvious that it is necessary to have some means of keeping track of just how each job is progressing pertaining to the necessary preparation of prints, routings, and such other work that must be completed prior to release of the job order to the Shop Scheduling Unit. The Methods Records Unit accomplishes these functions.

When a new part appears on the Production Breakdown Sheet, a folder containing the necessary information on the part is made up and sent to the Machine Tool Processing Unit where the Process Routing Sheet is made up on vellum paper. This accompanies the folder and is then sent to the Cost Estimating Unit via the MethodsRecords Unit so that they are able to tell at all times just what progress is being made on the "folder." The Cost Estimating Unit fills in the operator and set-up times in the proper columns on the Process Routing Sheet, and the folder is then returned to the Methods Records Unit for reproduction and distribution of the Process Routing Sheet. The folder is kept in a current file as long as the part is being produced in the plant.

Items of different forms are received by the Unit, reproduced in the required number and distributed according to the needs. For instance, Parts Lists are reproduced and sent to the following:

1. Original to file
2. Material Control
3. Assembly
4. Methods Processing

Blueprints are reproduced and sent to the following:

1. Original to file
2. Tool Design
3. Salvage
4. Machine shop
5. Assembly

Process Routing Sheets are reproduced and sent to the following:

1. Original vellum to file
2. Machine shop
3. Assembly
4. Inspection
5. Tool Design
6. Tool Room
7. Scheduling
8. Salvage

The Material Control Unit

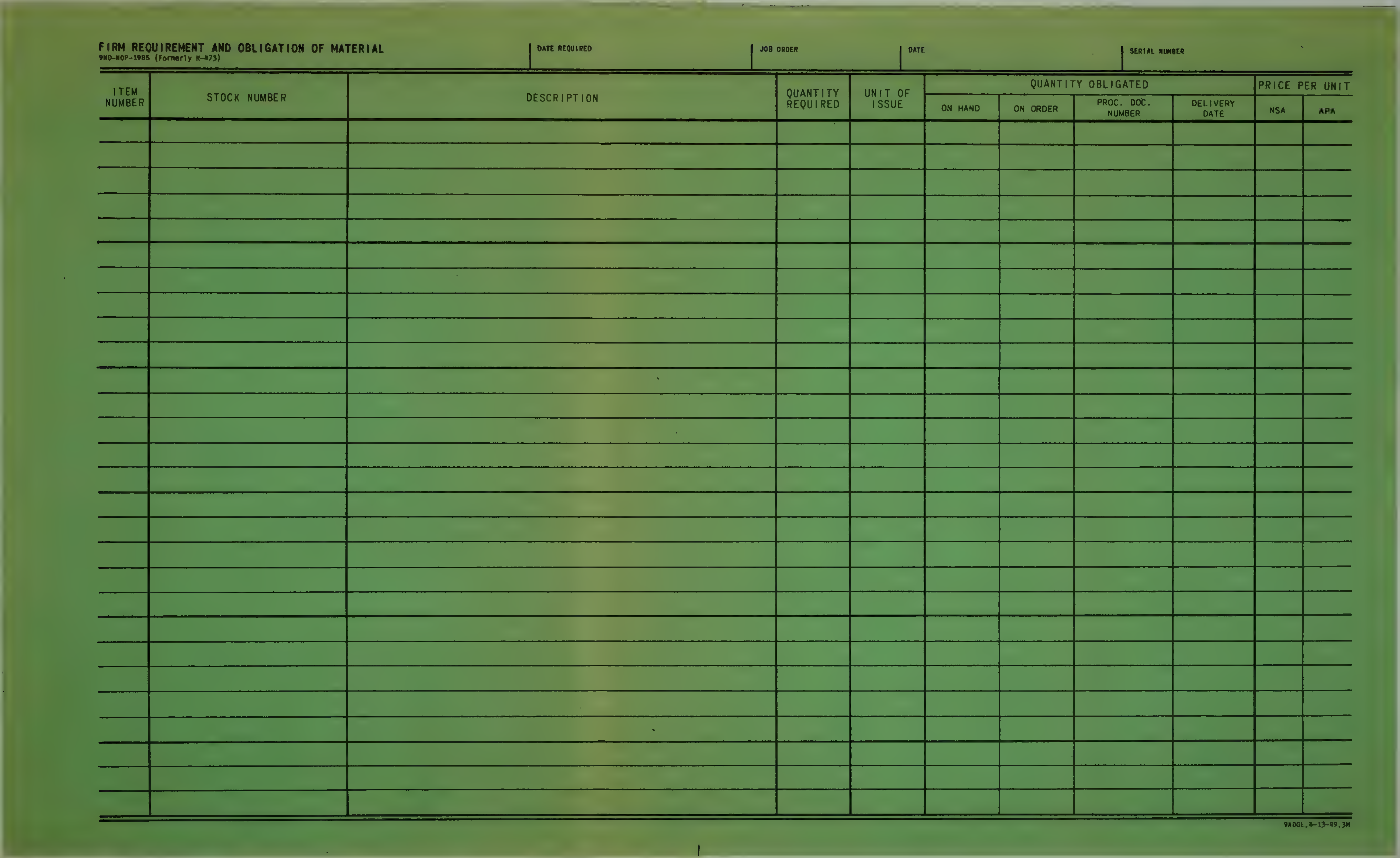
The Material Control Unit requisitions the raw materials and purchased parts required for the plant's production. It is responsible for initiating the screening of the supply system for available material, and for determining the component parts and their quantity to be manufactured in the plant.

In the interest of an economical material cost, the Unit, assisted by the Supply Department, investigates the required raw materials and purchased parts to determine the materials available in the extensive supply system. For this purpose the Unit originates the Firm Requirement and Obligation of Material Form, Figure 8. When the required material is available, the Unit requisitions it through the Supply Department, the procuring agency for raw materials and purchased parts.

The Production Breakdown Sheet, Figure 9, is issued by the Unit. This sheet contains information as to the quantity of each component part of a project, determined by the Unit from the parts list, prints, and an estimation of scrap and losses. The Production Breakdown Sheet, the authorization to manufacture a specific quantity of a component part, is widely distributed throughout the Production Control Division.

Also issued by the Unit is the Stub Requisition, Figure 10, for raw materials and purchased parts. It is the Unit's request for the Supply Department to procure the required raw material or purchased parts, either from the supply system or from a commercial concern.

The following diagram shows the flow of information into the Material Control Unit, the forms it originates, and the information which leaves the Unit.



FIRM REQUIREMENT AND OBLIGATION OF MATERIAL
9ND-NOP-1985 (Formerly N-473)

DATE REQUIRED

JOB ORDER

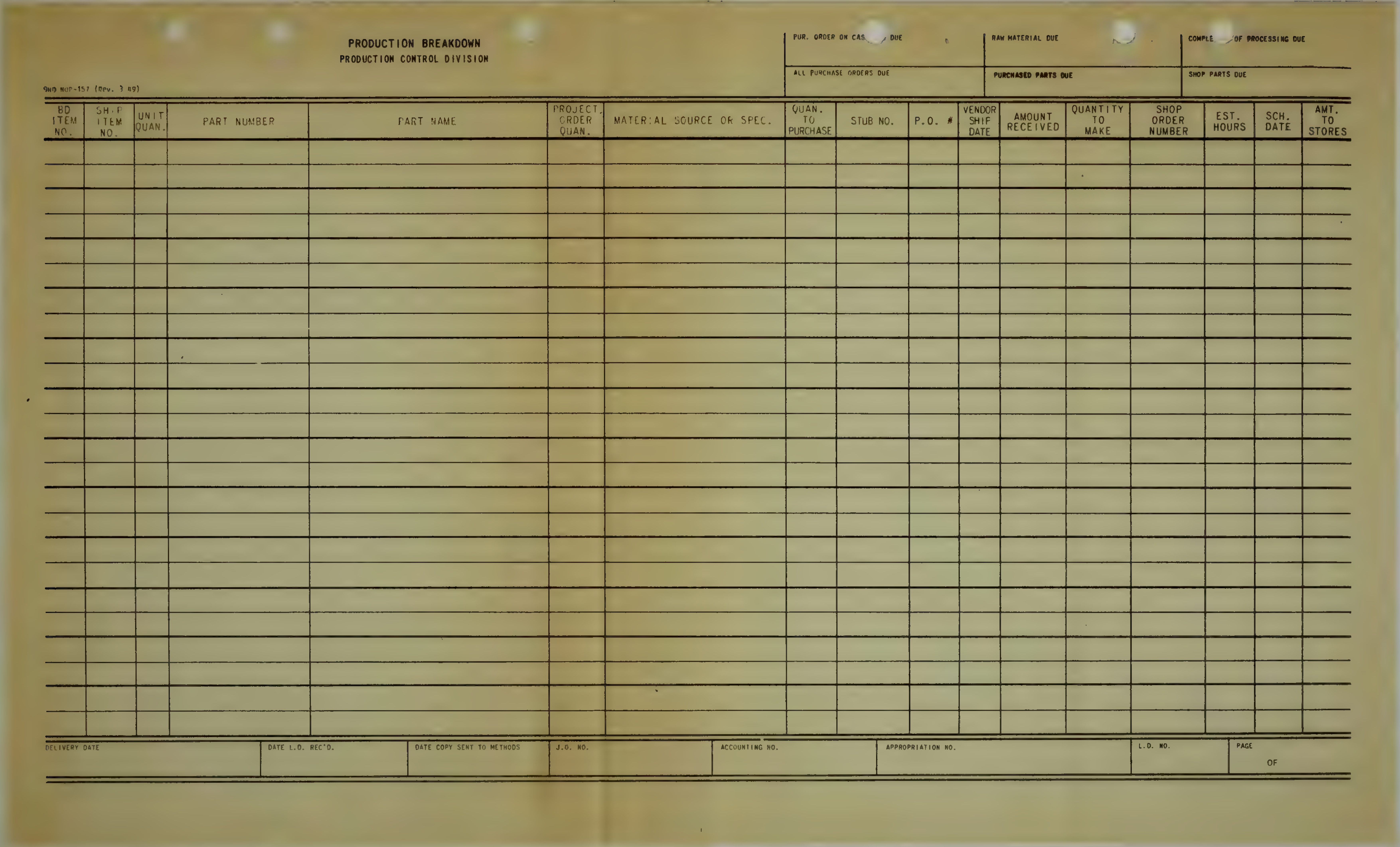
DATE

SERIAL NUMBER

ITEM NUMBER	STOCK NUMBER	DESCRIPTION	QUANTITY REQUIRED	UNIT OF ISSUE	QUANTITY OBLIGATED				PRICE PER UNIT	
					ON HAND	ON ORDER	PROC. DOC. NUMBER	DELIVERY DATE	NSA	APA

9NDGL,4-13-49,3M

Fig. 8 Firm Requirement and Obligation of Material Form



PRODUCTION BREAKDOWN
PRODUCTION CONTROL DIVISION

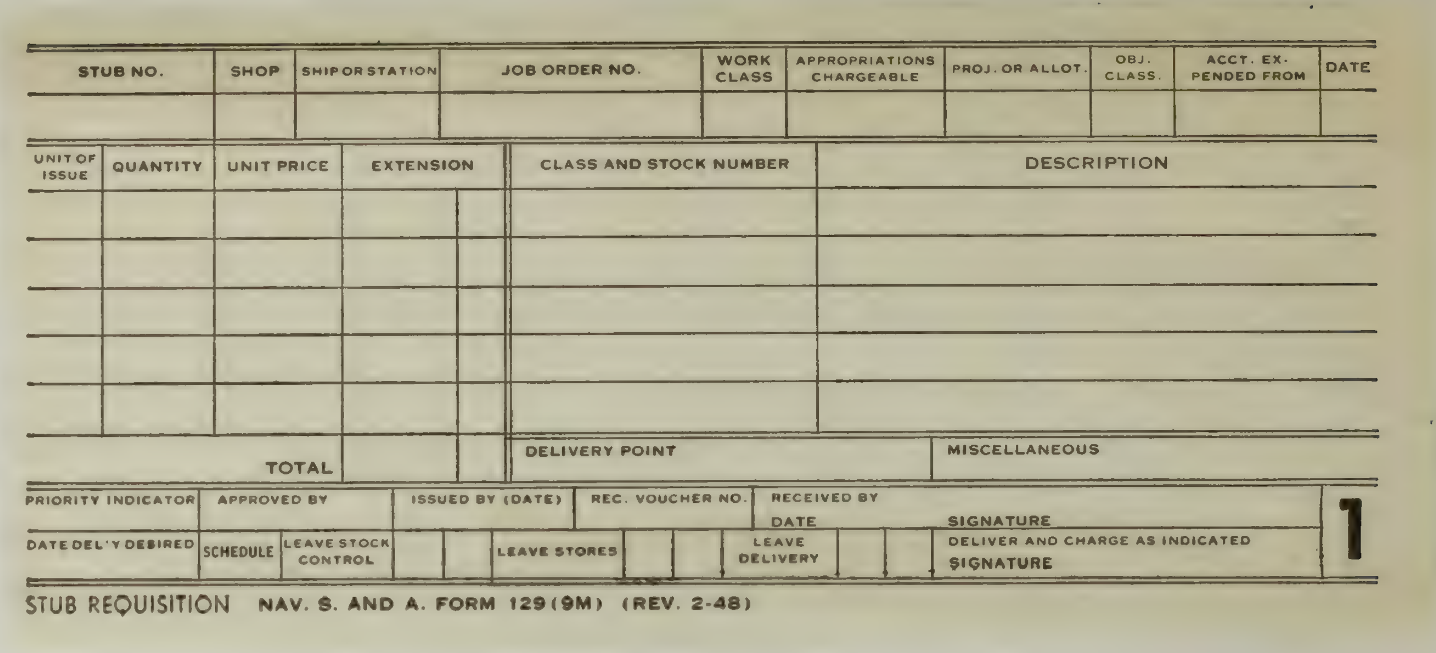
9ND NOP-157 (Rev. 3 49)

PUR. ORDER ON CAS[illegible] DUE	RAW MATERIAL DUE	COMPLE[illegible] OF PROCESSING DUE
ALL PURCHASE ORDERS DUE	PURCHASED PARTS DUE	SHOP PARTS DUE

BD ITEM NO.	SHIP ITEM NO.	UNIT QUAN.	PART NUMBER	PART NAME	PROJECT ORDER QUAN.	MATERIAL SOURCE OR SPEC.	QUAN. TO PURCHASE	STUB NO.	P.O. #	VENDOR SHIP DATE	AMOUNT RECEIVED	QUANTITY TO MAKE	SHOP ORDER NUMBER	EST. HOURS	SCH. DATE	AMT. TO STORES

DELIVERY DATE	DATE L.O. REC'D.	DATE COPY SENT TO METHODS	J.O. NO.	ACCOUNTING NO.	APPROPRIATION NO.	L.O. NO.	PAGE OF

Fig. 9 Production Breakdown Sheet



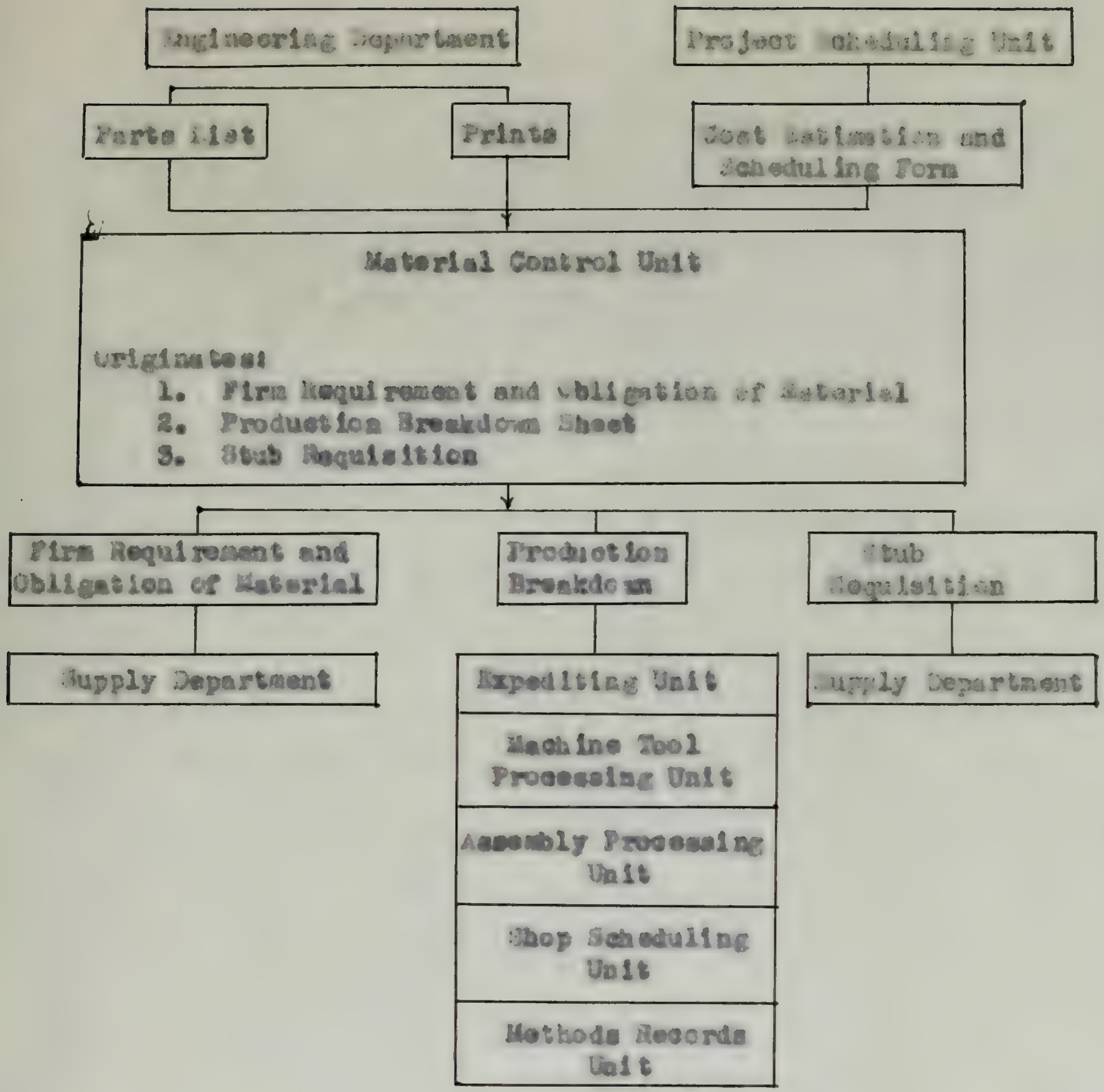
STUB NO.	SHOP	SHIP OR STATION	JOB ORDER NO.	WORK CLASS	APPROPRIATIONS CHARGEABLE	PROJ. OR ALLOT.	OBJ. CLASS.	ACCT. EX-PENDED FROM	DATE

UNIT OF ISSUE	QUANTITY	UNIT PRICE	EXTENSION		CLASS AND STOCK NUMBER	DESCRIPTION
		TOTAL			DELIVERY POINT	MISCELLANEOUS

PRIORITY INDICATOR	APPROVED BY		ISSUED BY (DATE)		REC. VOUCHER NO.	RECEIVED BY DATE	SIGNATURE	1
DATE DEL'Y DESIRED	SCHEDULE	LEAVE STOCK CONTROL		LEAVE STORES		LEAVE DELIVERY	DELIVER AND CHARGE AS INDICATED SIGNATURE	

STUB REQUISITION NAV. S. AND A. FORM 129 (9M) (REV. 2-48)

Fig. 10 Stub Requisition


Engineering Department
Project Scheduling Unit
Parts List
Prints
Cost Estimation and Scheduling Form
Material Control Unit
Originates:
1. Firm Requirement and Obligation of Material
2. Production Breakdown Sheet
3. Stub Requisition
Firm Requirement and Obligation of Material
Production Breakdown
Stub Requisition
Supply Department
Expediting Unit
Machine Tool Processing Unit
Assembly Processing Unit
Shop Scheduling Unit
Methods Records Unit
Supply Department

The Machine Tool Processing Unit

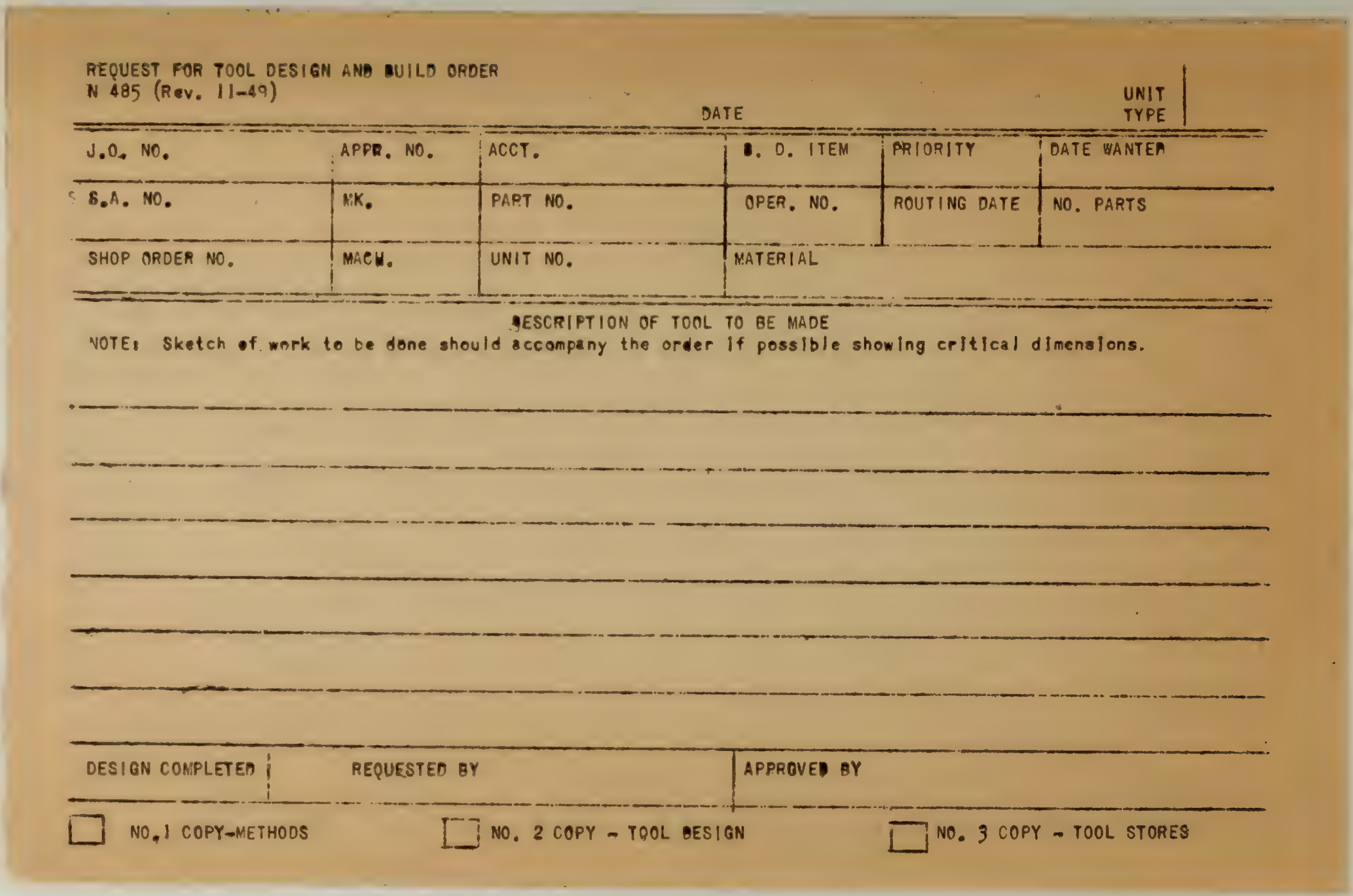
The Machine Tool Processing Unit originates the operation sheet for each component part to be manufactured in the plant, and issues requests for the designing and building of the special tools, jigs, fixtures, and gages required in the manufacture of these component parts.

This unit performs the work normally assigned in industry to the Production Planning Department. The Process Routing (or operation) Sheet, Figure 11, is one of the most important records kept by a manufacturing company, representing the "know-how" in the manufacture of component parts. It is formulated from the Parts List, Production Breakdown, and Internal Schedule received by the Unit.

The Tool Design and Build Order Form, Figure 12, is originated in the Unit from the information contained in the Parts List, the Production Breakdown, and the Process Routing Sheet. It outlines in general terms the tools, jigs, fixtures, and gages which the Tooling Division designs and builds for the manufacture of the component parts.

The following diagram shows the flow of information to the Machine Tool Processing Unit, the material originated in the Unit, and the next destination of that material.

Fig. 11 Process Routing Sheet



REQUEST FOR TOOL DESIGN AND BUILD ORDER
N 485 (Rev. 11-49)

DATE

UNIT TYPE

J.O. NO.	APPR. NO.	ACCT.	B. D. ITEM	PRIORITY	DATE WANTED
S.A. NO.	MK.	PART NO.	OPER. NO.	ROUTING DATE	NO. PARTS
SHOP ORDER NO.	MACH.	UNIT NO.	MATERIAL		

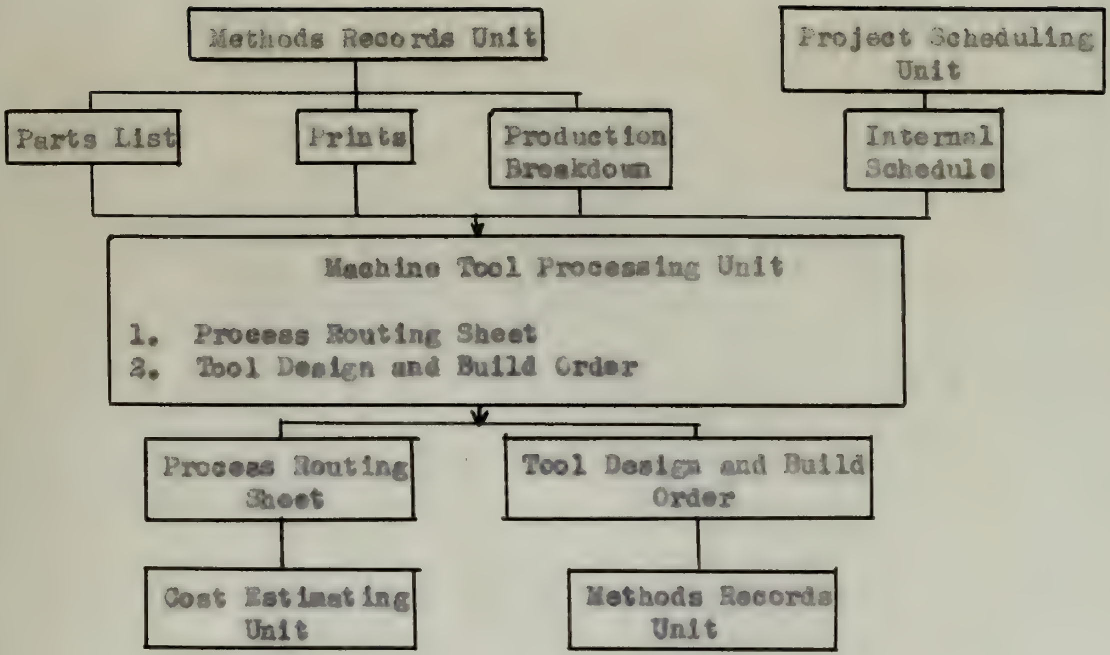
DESCRIPTION OF TOOL TO BE MADE

NOTE: Sketch of work to be done should accompany the order if possible showing critical dimensions.

DESIGN COMPLETED	REQUESTED BY	APPROVED BY

☐ NO. 1 COPY-METHODS ☐ NO. 2 COPY - TOOL DESIGN ☐ NO. 3 COPY - TOOL STORES

Fig. 12 Tool Design and Build Order Form


Methods Records Unit
Project Scheduling Unit
Parts List
Prints
Production Breakdown
Internal Schedule
Machine Tool Processing Unit
1. Process Routing Sheet
2. Tool Design and Build Order
Process Routing Sheet
Tool Design and Build Order
Cost Estimating Unit
Methods Records Unit

The Assembly Processing Unit

The Assembly Processing Unit originates the assembly operation sheet and issues orders for the tools, jigs, fixtures, gages, and test equipment required for the assembly process.

The specialization of the plant's final product, aviation fire control equipment, requires a great amount of assembly work. Since the knowledge of instrument assembly is highly technical, the Unit must provide a detailed write-up of the assembly of an aviation fire control system.

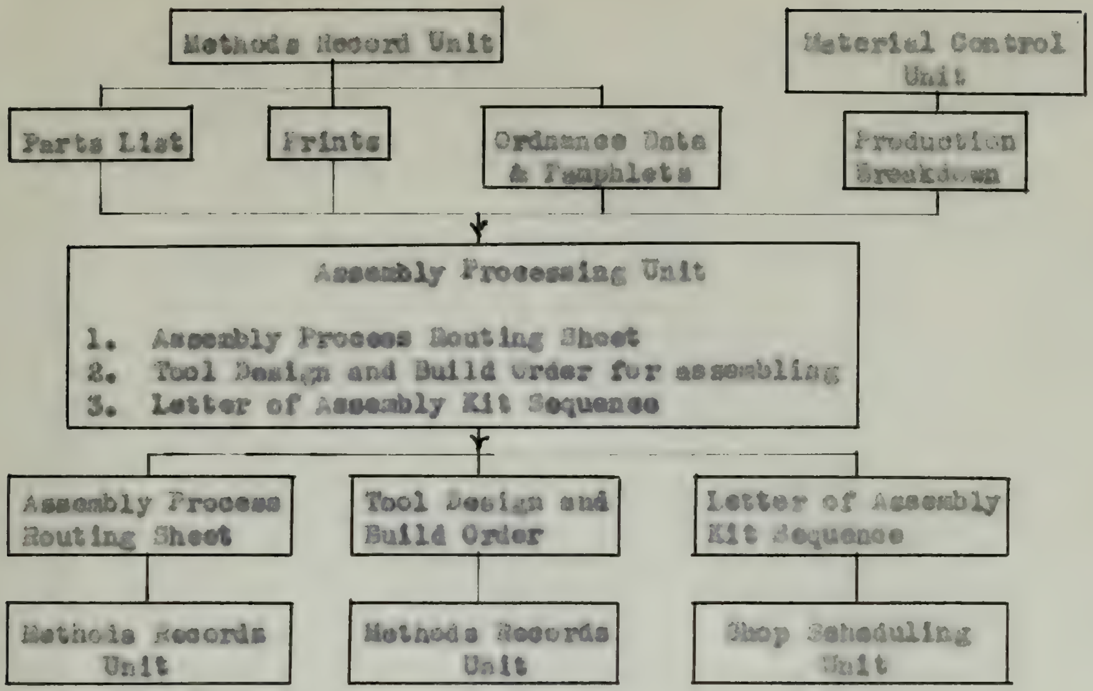
The Assembly Process Routing Sheet, in form similar to Figure 11, is originated in the Assembly Processing Unit. Experience is the most important factor in the writing of this sheet, which is constructed from the information contained in the Parts List, the Prints, and the Production Breakdown Sheet.

The Tool Design and Build Order Form, similar to Figure 12, is based on information from the Parts List, Prints, and Assembly Process Routing Sheet. The Assembly Process Routing Sheet also includes details of the required inspections; the Unit orders the special test equipment for these inspections. In some cases available commercial equipment is modified for this purpose, while in others special test equipment must be designed.

Equipment must be assembled in a definite sequence of operations; the Shop Scheduling Unit is furnished this information in the form of a letter, the Letter of Assembly Kit Sequence, which is a guide to the proper sequence of issuing the Assembly Kit.

The following diagram shows the flow of the more important information into the Unit, the material originated in the Unit, and the

information departing from it.


Methods Record Unit
Material Control Unit
Parts List
Prints
Ordnance Data & Pamphlets
Production Breakdown
Assembly Processing Unit
1. Assembly Process Routing Sheet
2. Tool Design and Build Order for assembling
3. Letter of Assembly Kit Sequence
Assembly Process Routing Sheet
Tool Design and Build Order
Letter of Assembly Kit Sequence
Methods Records Unit
Methods Records Unit
Shop Scheduling Unit

The Cost Estimating Unit

The Cost Estimating Unit originates an estimated cost of each project undertaken by the plant, including the project's direct labor and material costs.

The component parts to be manufactured in the plant are estimated from information received from the Material Control Unit and other sources. The Cost Estimate Work Sheet, Figure 13, is used to compile data and compute total costs; this information is transferred to the Cost Estimation and Scheduling Form.

Probable operations and the time required for each are estimated by the Unit. The Machine Tool Processing Unit and the Assembly Processing Unit assist in the estimation of the operations required for the manufacture of each component part. This data is entered on the Estimate Routing Sheet, Figure 14.

The time in man-hours required for each operation, including the machine tool set-up time is estimated from past experience by the Unit.

As an aid to the maintenance of an accurate estimate of labor time required for each operation, the Unit records the actual time required at the completion of the job. With this information available, the Unit is able to keep current the time estimates in relation to the actual operation time. The estimated times are recorded on the Cost Estimate Work Sheet and the Process Routing Sheet.

The Unit keep the Material Cost Card, Figure 15, for the purpose of estimating the project's material cost. Information from the purchase orders, which contain the current cost of materials, is transferred to the Material Cost Card which furnishes an up-to-date record

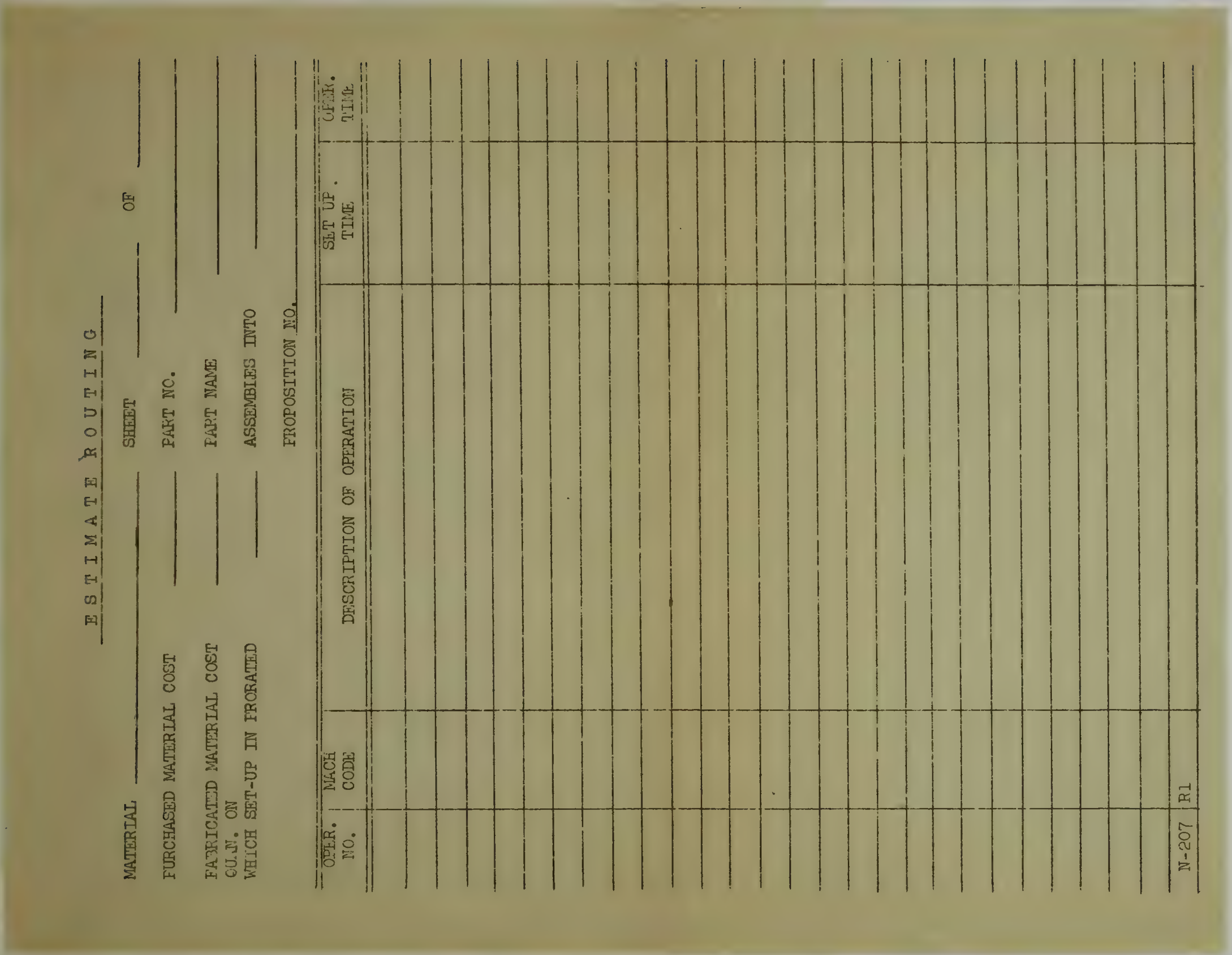
9ND-NOP-286

COST ESTIMATE WORK SHEET

SHEET OF SHEETS PARTS LIST NO. PROP. NO. PJO NO. P. OR R NO. DATE

ITEM	PART NUMBER	DESCRIPTION	MAKE OR PUR.	QUANTITY	MATERIAL COST				STD. TIME PER PIECE		DIRECT LABOR COST			
					FABRICATED		PURCHASED		ASSEMBLY	MACH. TOOL	ASSEMBLY @		MACHINE TOOL @	
					UNIT	TOTAL	UNIT	TOTAL	UNIT HR.	UNIT HR.	UNIT	TOTAL	UNIT	TOTAL

9NDGL,7-15-47,500



ESTIMATE ROUTING

MATERIAL ____ SHEET ____ OF ____

PURCHASED MATERIAL COST ____ PART NO. ____

FABRICATED MATERIAL COST ____ PART NAME ____

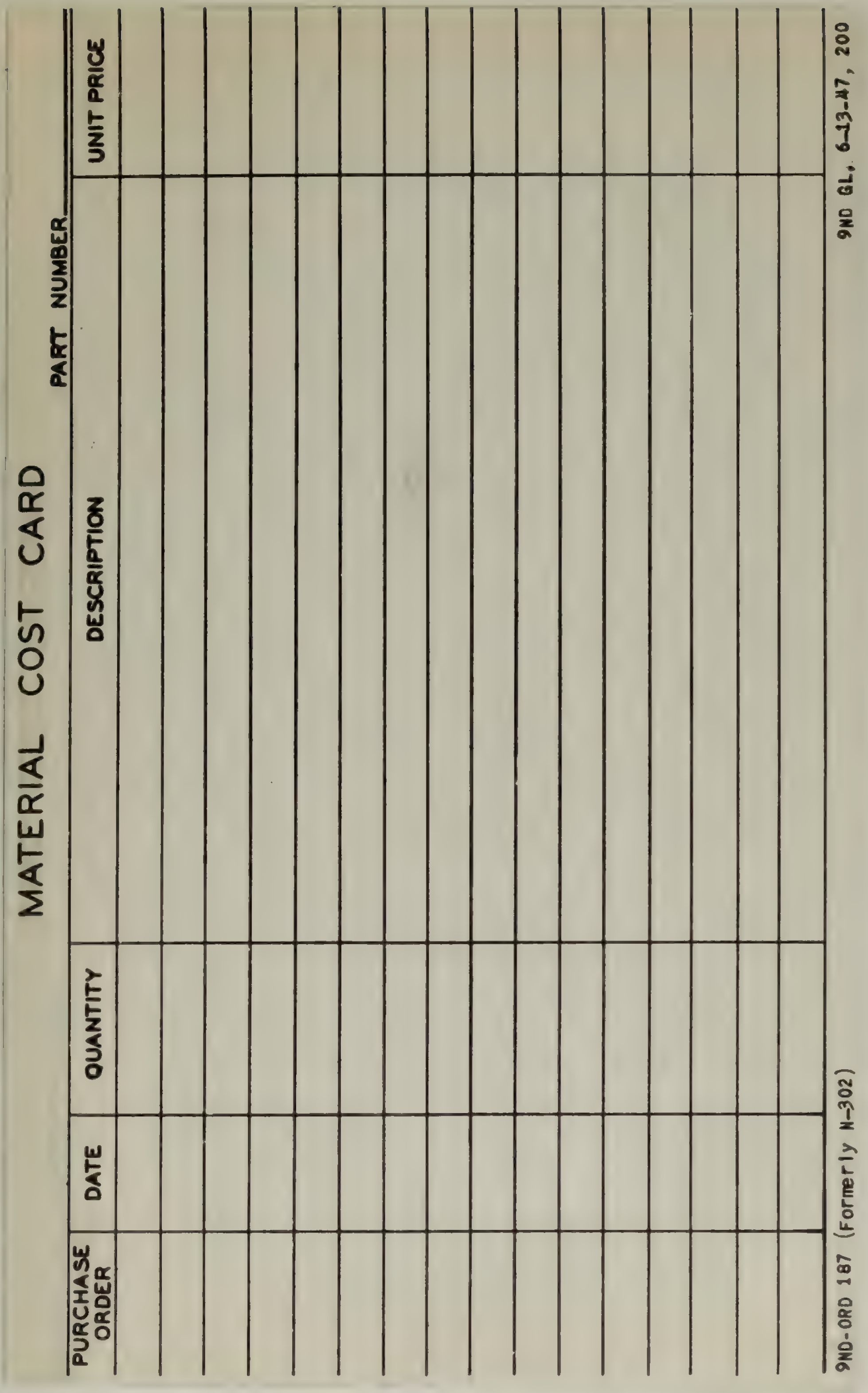
CU.N. ON WHICH SET-UP IN PRORATED ____ ASSEMBLIES INTO ____

PROPOSITION NO. ____

OPER. NO.	MACH CODE	DESCRIPTION OF OPERATION	SET UP TIME	OPER. TIME

N-207 R1

Fig. 14 Estimate Routing Sheet



MATERIAL COST CARD

PART NUMBER

PURCHASE ORDER	DATE	QUANTITY	DESCRIPTION	UNIT PRICE

9ND-ORD 187 (Formerly N-302)

9ND GL, 6-13-47, 200

Fig. 15 Material Cost Card

MATERIAL COST CARD

PART NUMBER ____________

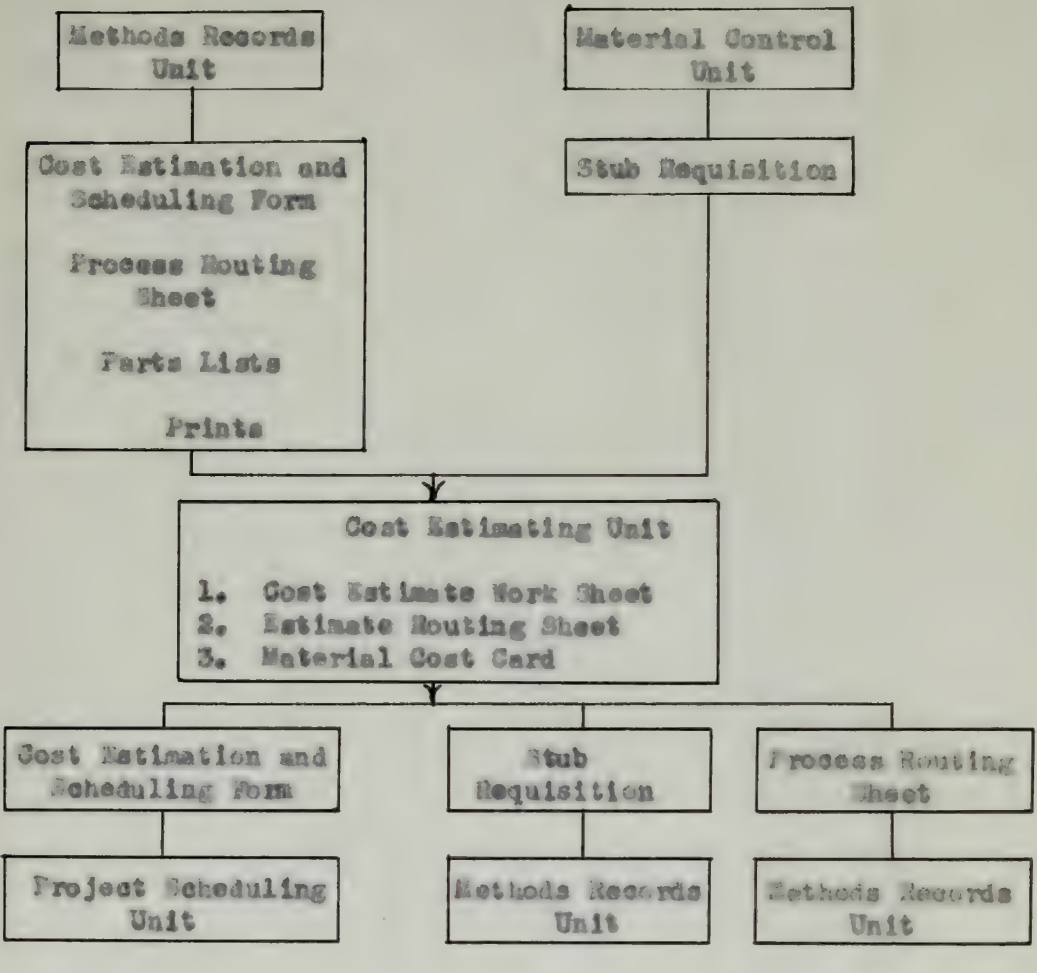
PURCHASE ORDER	DATE	QUANTITY	DESCRIPTION	UNIT PRICE

[illegible]　　980 GL, 6-13-47 [illegible]

Fig. 32 Material Cost Card

of material costs for the Unit.

The following diagram shows the flow of information into, through, and out of the Cost Estimating Unit.



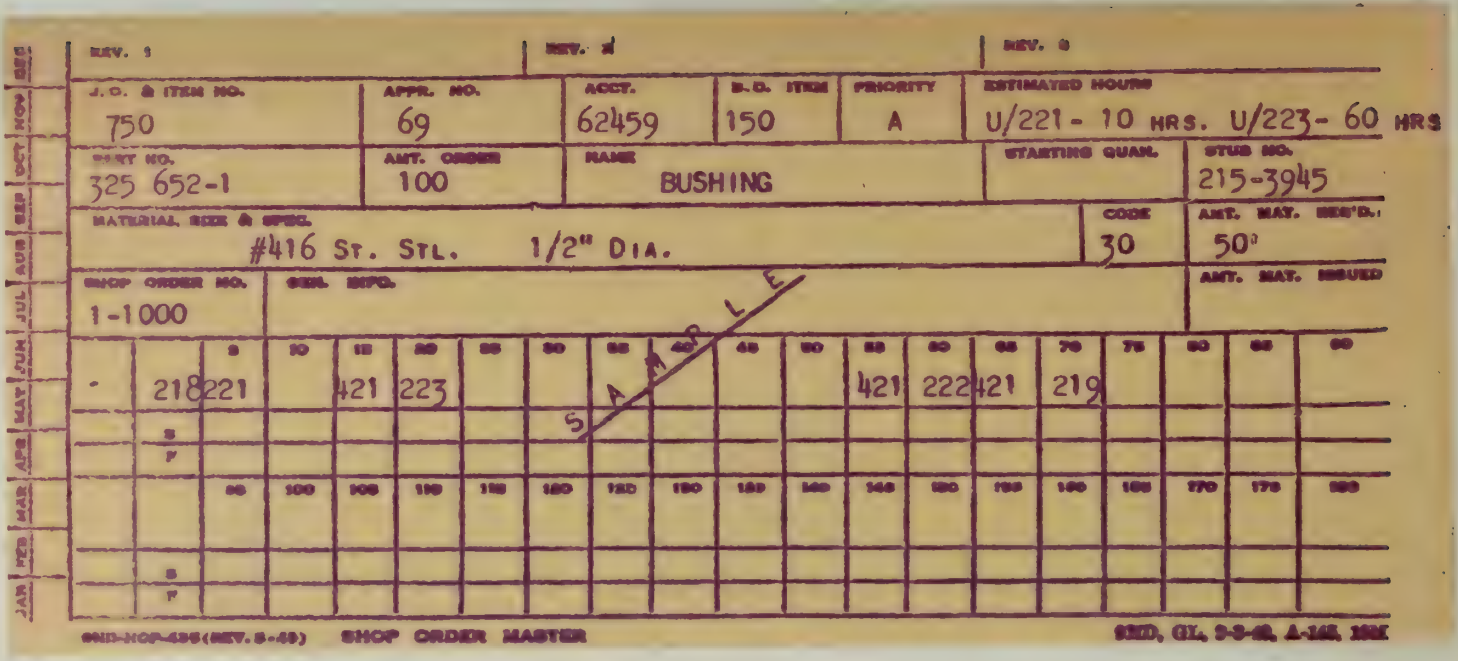
The Shop Scheduling Unit

The Shop Scheduling Unit assigns to the Machining Division the manufacture of the component parts and to the Assembly Divisions the assembly of these parts into completed items. The Unit maintains a current record of work load in man-hours, which forms the basis for the addition of new work to the shop.

Figure 16 shows the Shop Order Kit, the shop's authority to manufacture a component part on assembly. This form is compiled from information contained in the Process Routing and Production Breakdown Sheets and the Internal Schedule Form. The required month date of the component part's completion is given on the Shop Order Kit. The shop is thus scheduled for work by months in terms of man-hours. The Shop Order Kit consists of eight vari-colored IBM cards, each color having a specific usage. The yellow material identification card is the master card, accompanying the shop order from raw material to completed component part; the green card is the material requisition card, etc.

The Weekly Machine Load Summary, Figure 17, is issued by the Unit. It serves as a means of determining the relative operating efficiency of the various units of the Production Division, and is the basis for adding new work to the shop and adjusting potential man-hours of labor between the Production Divisions. This report contains information on the number of man-hours released to and completed by the shop, and the present amount of work available for the shop.

The Unit issues the Assembly Monthly Schedule which establishes the sequence of work to be accomplished by the Assembly Division during a month. Since there are many unpredictable time-consuming variables in the assembly of a highly complex instrument, the Assembly Division



JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

REV. 1 REV. 2 REV. 3

J.O. & ITEM NO. 750	APPR. NO. 69	ACCT. 62459	B.O. ITEM 150	PRIORITY A	ESTIMATED HOURS U/221 - 10 HRS. U/223 - 60 HRS
PART NO. 325 652-1	AMT. ORDER 100	NAME BUSHING		STARTING QUAN.	STUB NO. 215-3945
MATERIAL, SIZE & SPEC. #416 St. Stl. 1/2" Dia.				CODE 30	AMT. MAT. REQ'D. 50'
SHOP ORDER NO. 1-1000	GEN. INFO.				AMT. MAT. ISSUED

SAMPLE

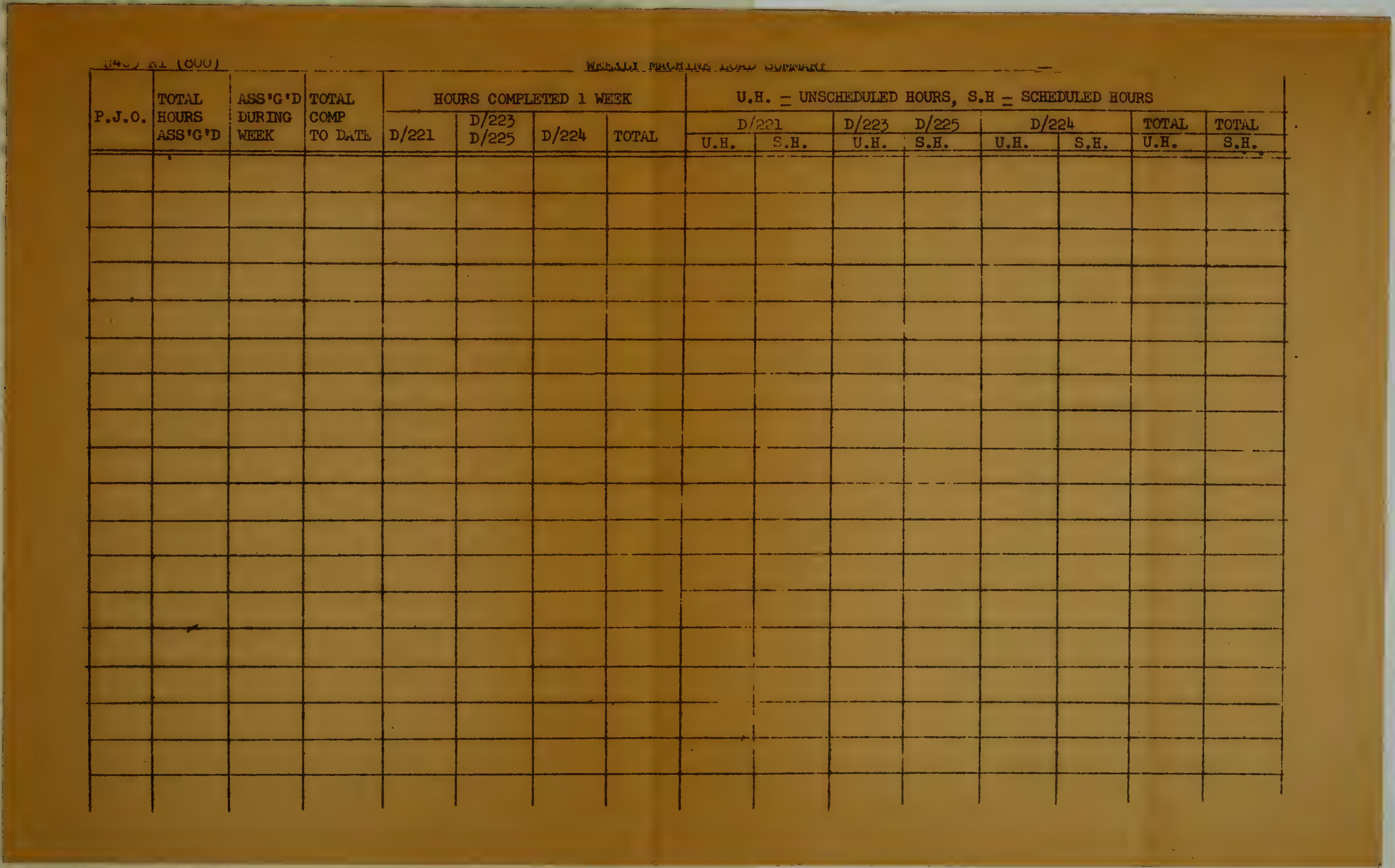
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
-	218	221		421	223							421	222	421	219				
	S																		
	F																		
		95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180
	S																		
	F																		

SND-HOP-436 (REV. 5-48) SHOP ORDER MASTER

SSD, GL, 9-3-48, A-145, 10M

Fig. 16 Shop Order Kit

[illegible]



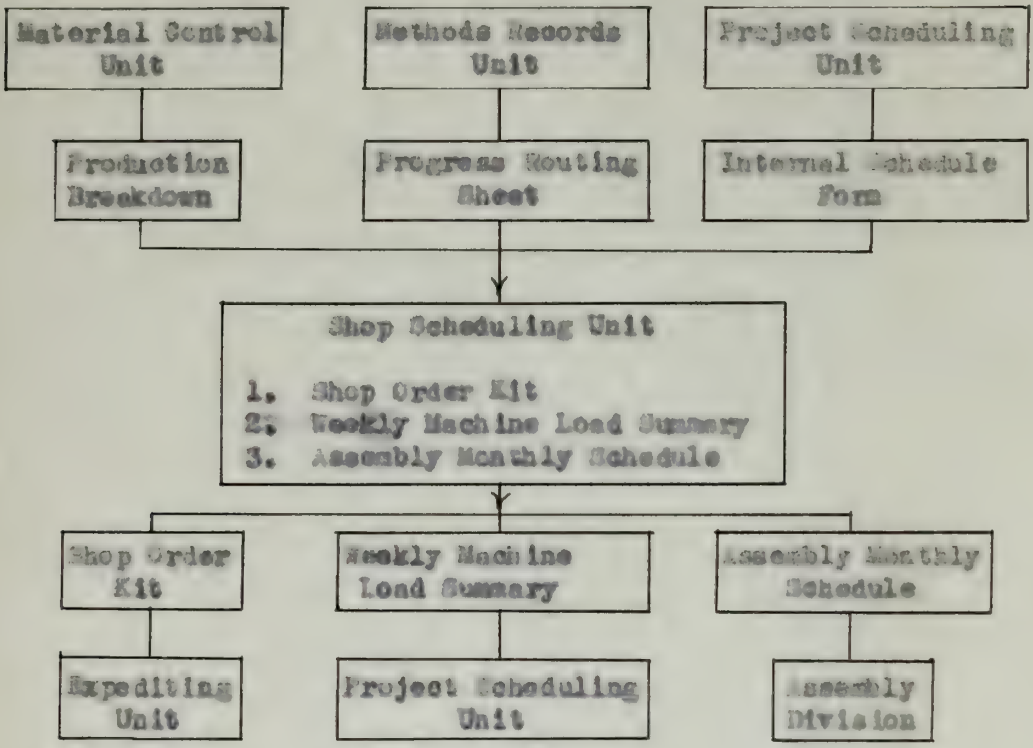
(840) R1 (800) WEEKLY MACHINE LOAD SUMMARY

P.J.O.	TOTAL HOURS ASS'G'D	ASS'G'D DURING WEEK	TOTAL COMP TO DATE	HOURS COMPLETED 1 WEEK				U.H. = UNSCHEDULED HOURS, S.H = SCHEDULED HOURS							
				D/221	D/223 D/225	D/224	TOTAL	D/221		D/223	D/225	D/224		TOTAL	TOTAL
								U.H.	S.H.	U.H.	S.H.	U.H.	S.H.	U.H.	S.H.

Fig. 17 Weekly Machine Load Summary

is not scheduled for work in terms of man-hours per month. The probable time required is available in a rough estimate, from which data the Assembly Monthly Schedule lists the projects' priorities and the required monthly delivery rates of the assembly units. Normally, the Assembly Monthly Schedule overloads the Assembly Divisions in terms of man-hours of assembly work.

The important forms received in, originated by, and sent from the Unit appear below.



The Expediting Unit

The Expediting Unit is charged with the responsibility of seeing that the materials for a shop order are located physically in the plant prior to sending the shop orders to the shop and that all shop schedules are met. The Expediting Unit initiates suggestions for substitute materials, and originates requests for new work to replace the "rejects" on job orders.

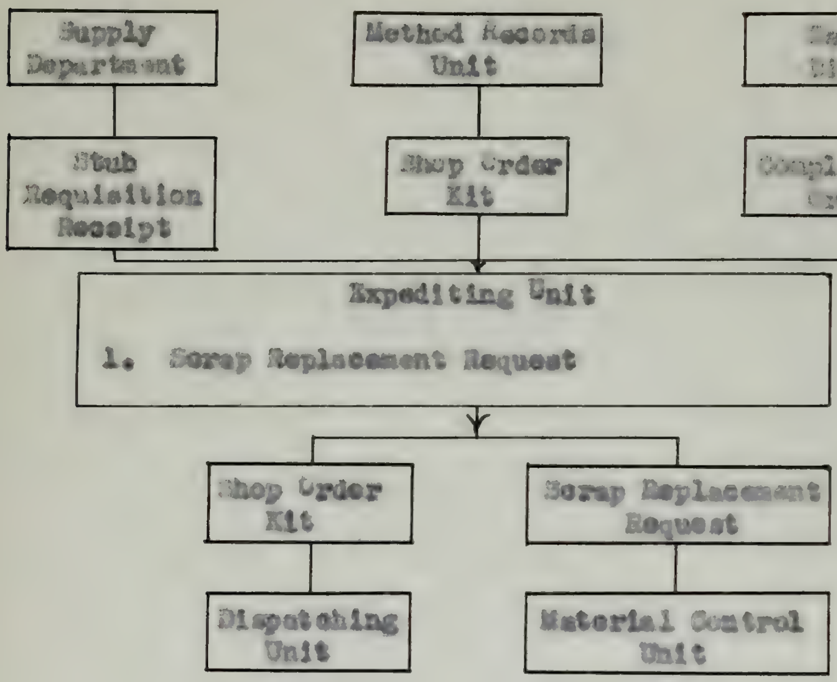
In order to prevent confusion in the shop, Shop Order Kits are not released for manufacture until the necessary raw materials for them have been received in the plant.

After receiving the Shop Order Kit from the Method Records Unit, the Expediting Unit holds the kit until the Stub Requisition Receipt is received. This receipt is issued by the Supply Department after the material has been received. The Unit maintains a records of all Shop Order Kits and the required material for each; it also makes a weekly check of all kits being held up because of a lack of materials. A bi-monthly record of all such held-up kits is sent to the head of the Production Control Division. The Unit expedites the procuring of materials through the Supply Department. In some cases, the Unit originates a substitute material upon the approval of the Methods Section or the Engineering Division. In other cases, such a suggestion for substitutes comes from the shop or the Supply Department; the Unit is responsible for having these suggestions approved by the Methods Section or the Engineering Division.

When parts are rejected by the Inspection Division and scrapped by the Salvage Division, the information is recorded on the back of the Master Card in the Shop Order Kit. After the Expediting Unit receives

the Master Card, it originates a "scrap replacement request." This form is sent to the Material Control Unit, after which it is handled in the same manner as the original Shop Order Kit.

A general work flow diagram of the Expediting Unit is shown in the chart below.



The Dispatching Unit

The Dispatching Unit is responsible for the releasing of work to the shop and assembly divisions in accordance with the schedule. The Unit performs "trouble-shooting" activities to coordinate the materials, machine tools, and work for the Production Division. The records charting the progress of the assigned work are kept by the Unit. The material handling problems of the plant are also a responsibility of the Dispatching Unit.

The Shop Order Kit is received from the Expediting Unit, and, with the exception of the Material Requisition Card, the kit is placed in the appropriate pocket board. The pocket boards are arranged by Machining and Assembly Units by months. The Shop Order Kit is taken from the pocket board by the Head of the Unit, who establishes the sequence of work in his unit, based upon the completion date on the Shop Order Kit. To start a new job, the operator obtains the Material Requisition Card from the Dispatching Unit, and draws the required material. The Unit assists in the movement of materials from the storeroom to the workplace. The Unit transfers the partially completed job to the next scheduled Unit, and the Shop Order Kit to the appropriate pocket board of the next scheduled Unit. Thus, the location of the Shop Order Kit in the pocket board serves as a progress record of the job. The high priority Shop Order Kits are designated by a special color code, and these jobs are given special expediting attention.

The Dispatcher's File Card, Figure 18, is used to record progress of the shop orders and tool shortages. The Unit makes a daily floor check, gathering the data on the operations on the jobs in process. This data is recorded on the Dispatcher's File Card.

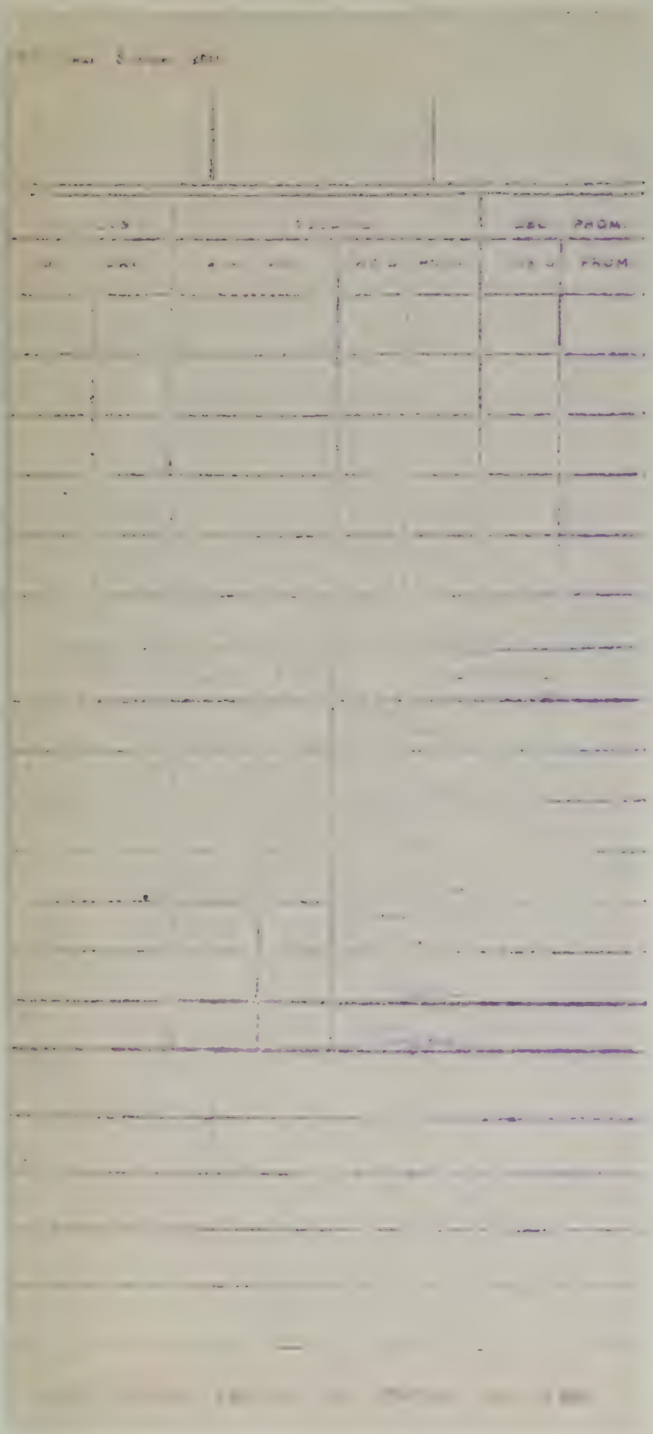
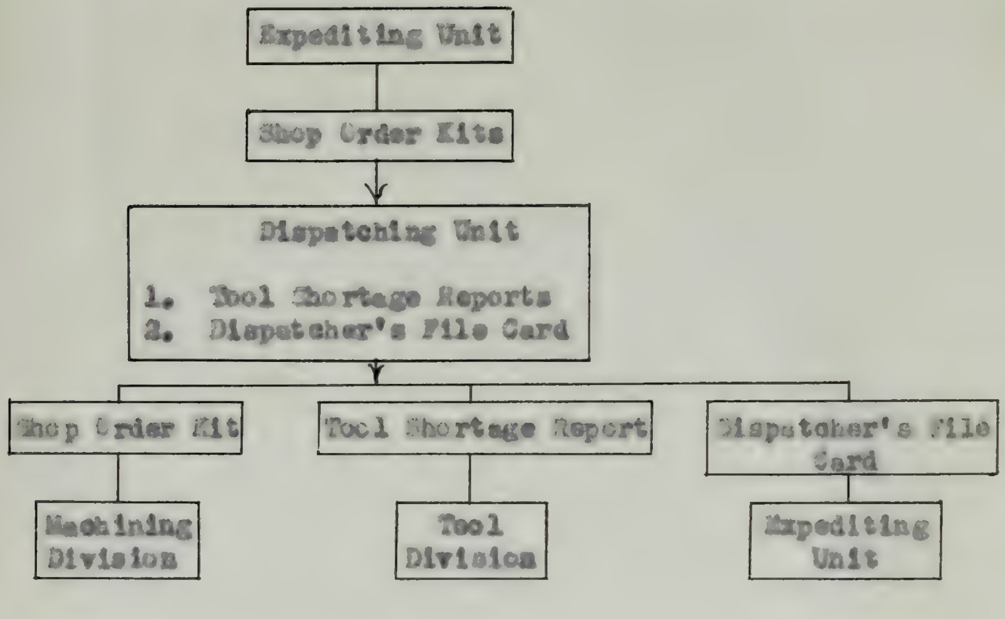
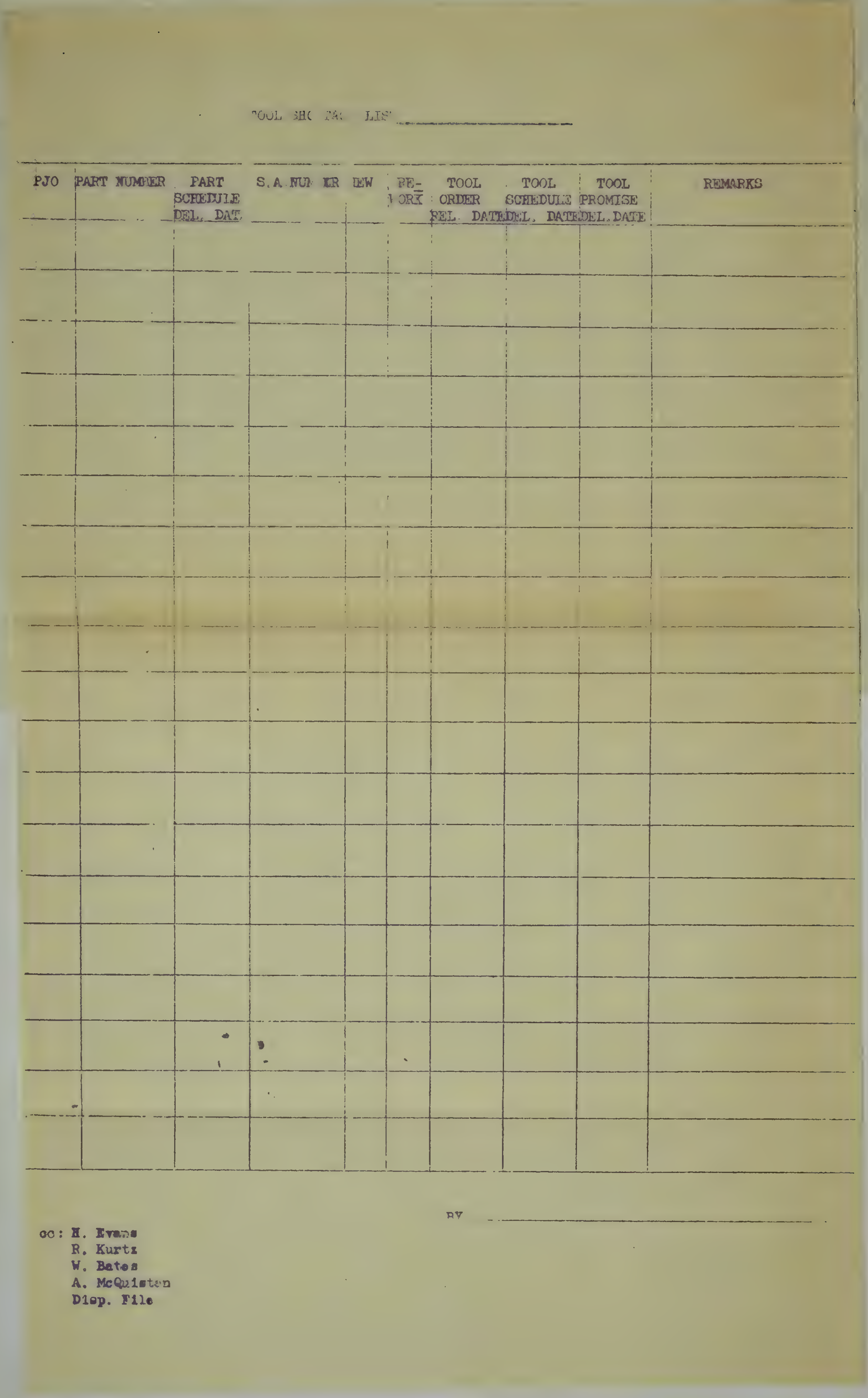


Fig. 18 Dispatcher's File Card

The Tool Shortage Report, Figure 15, is a report to the Tool Division, listing the jobs being held up because of a lack of tools. This report is submitted weekly, and its information is derived from the date gathered on the daily floor checks.

The flow of information into, the originated forms, and the forms departing from the Unit are shown in the diagram below.





TOOL SHORTAGE LIST ____________________

PJO	PART NUMBER	PART SCHEDULE DEL. DATE	S.A. NUMBER	NEW	RE-WORK	TOOL ORDER REL. DATE	TOOL SCHEDULE DEL. DATE	TOOL PROMISE DEL. DATE	REMARKS

BY ____________________

cc: H. Evans
R. Kurtz
W. Bates
A. McQuisten
Disp. File

Fig. 19 Tool Shortage Report

The Cost Control Unit

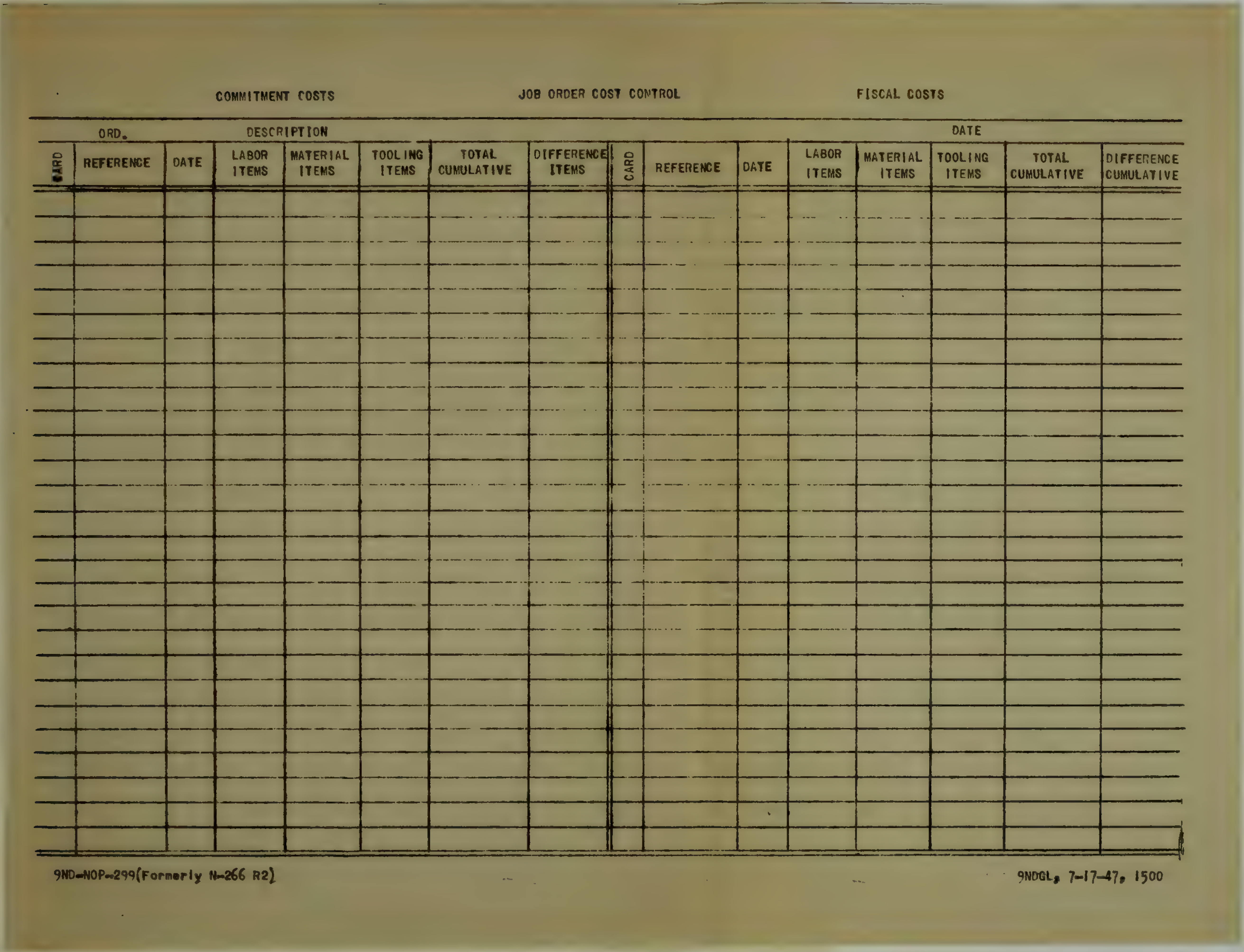
The Cost Control Unit records the commitment and expenditure of funds for the various productive projects, and analyzes estimates and expenditures to aid in locating discrepancies. The overhead budget for the Industrial Department is prepared by the Cost Control Unit.

The Job Order Cost Control Record, Figure 20, is maintained by the Unit, information being transferred to this record from the Stub Requisition, Purchase Orders, Public Vouchers, and Closed Shop Order Tabulations. This record is an accumulative financial sheet giving the amount of funds available, the amount expended to date, and the amount remaining for the job. Also shown is the variance between the estimated and the actual cost of each job order, as well as the accumulated variance.

The Request for Revision of Job Order Estimates is in the form of a letter, used to request additional funds for a job order when it is apparent from the Job Order Cost Control Record that the allotted funds are not sufficient. This request is sent through the head of the Production Control Division to the plant's administration.

Also in the form of a letter, the Shop Order Report is submitted to the Cost Estimating Unit and the Machining Division, showing the variation between the estimated and actual labor hours of the shop order. This report presents variance data to be investigated by the Cost Estimating Unit and the Machining Division. Information contained in the Shop Order Report is taken from the Job Order Cost Control Record.

The Request for Station Maintenance Funds for the Industrial Department, Figure 21, is made up by the Unit from information contained in the Department Budget Report, the Leave Analysis Report, and the



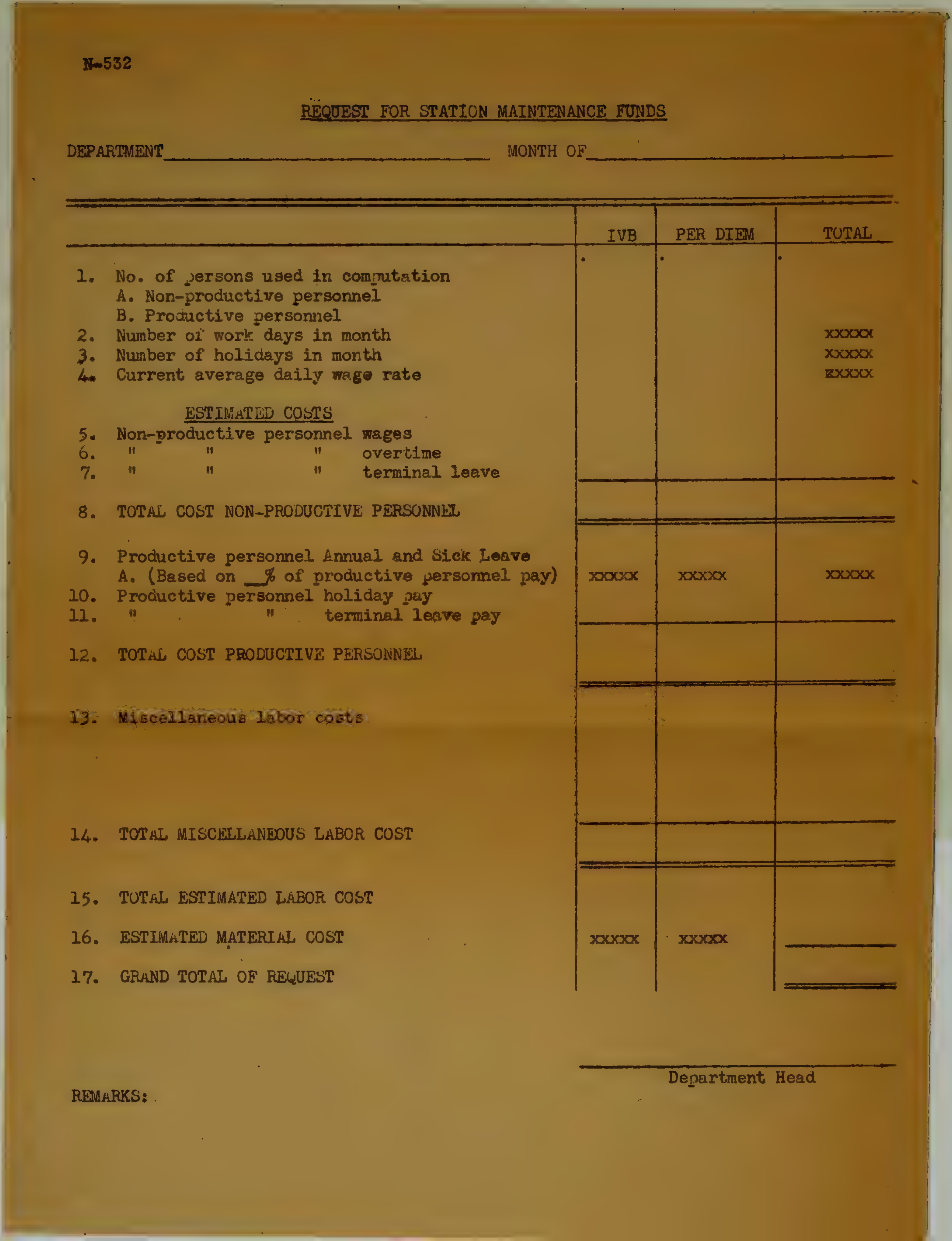
COMMITMENT COSTS JOB ORDER COST CONTROL FISCAL COSTS

ORD. DESCRIPTION DATE

CARD	REFERENCE	DATE	LABOR ITEMS	MATERIAL ITEMS	TOOLING ITEMS	TOTAL CUMULATIVE	DIFFERENCE ITEMS	CARD	REFERENCE	DATE	LABOR ITEMS	MATERIAL ITEMS	TOOLING ITEMS	TOTAL CUMULATIVE	DIFFERENCE CUMULATIVE

9ND-NOP-299(Formerly N-266 R2) 9NDGL, 7-17-47, 1500

Fig. 20 Job Order Cost Control Record



N-532

REQUEST FOR STATION MAINTENANCE FUNDS

DEPARTMENT__________________ MONTH OF__________________

	IVB	PER DIEM	TOTAL
1. No. of persons used in computation			
A. Non-productive personnel			
B. Productive personnel			
2. Number of work days in month			xxxxx
3. Number of holidays in month			xxxxx
4. Current average daily wage rate			xxxxx
ESTIMATED COSTS			
5. Non-productive personnel wages			
6. " " " overtime			
7. " " " terminal leave			
8. TOTAL COST NON-PRODUCTIVE PERSONNEL			
9. Productive personnel Annual and Sick Leave			
A. (Based on __% of productive personnel pay)	xxxxx	xxxxx	xxxxx
10. Productive personnel holiday pay			
11. " " terminal leave pay			
12. TOTAL COST PRODUCTIVE PERSONNEL			
13. Miscellaneous labor costs			
14. TOTAL MISCELLANEOUS LABOR COST			
15. TOTAL ESTIMATED LABOR COST			
16. ESTIMATED MATERIAL COST	xxxxx	xxxxx	
17. GRAND TOTAL OF REQUEST			

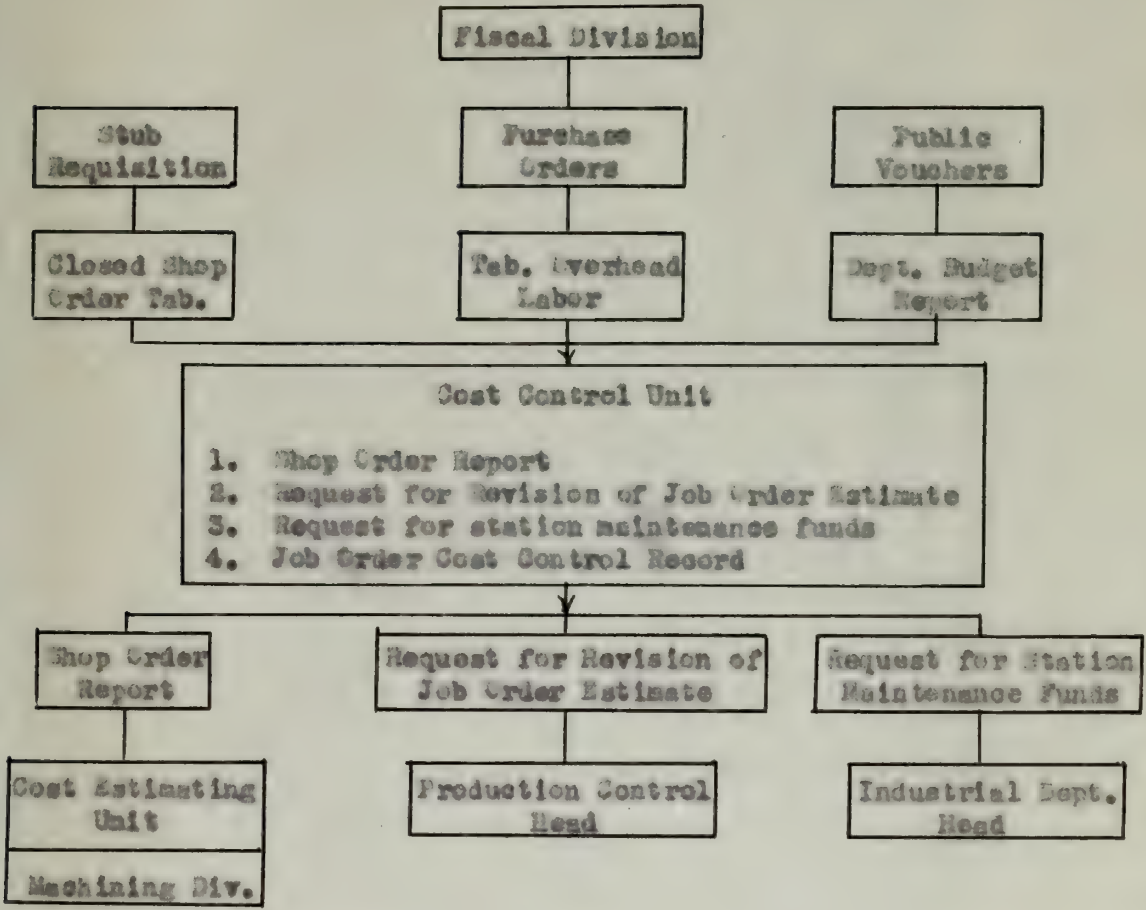
Department Head

REMARKS:

Fig. 21 Request for Station Maintenance Funds

Tabulation Overhead Labor Report. This request consists of estimates of the required overhead funds for the Industrial Department.

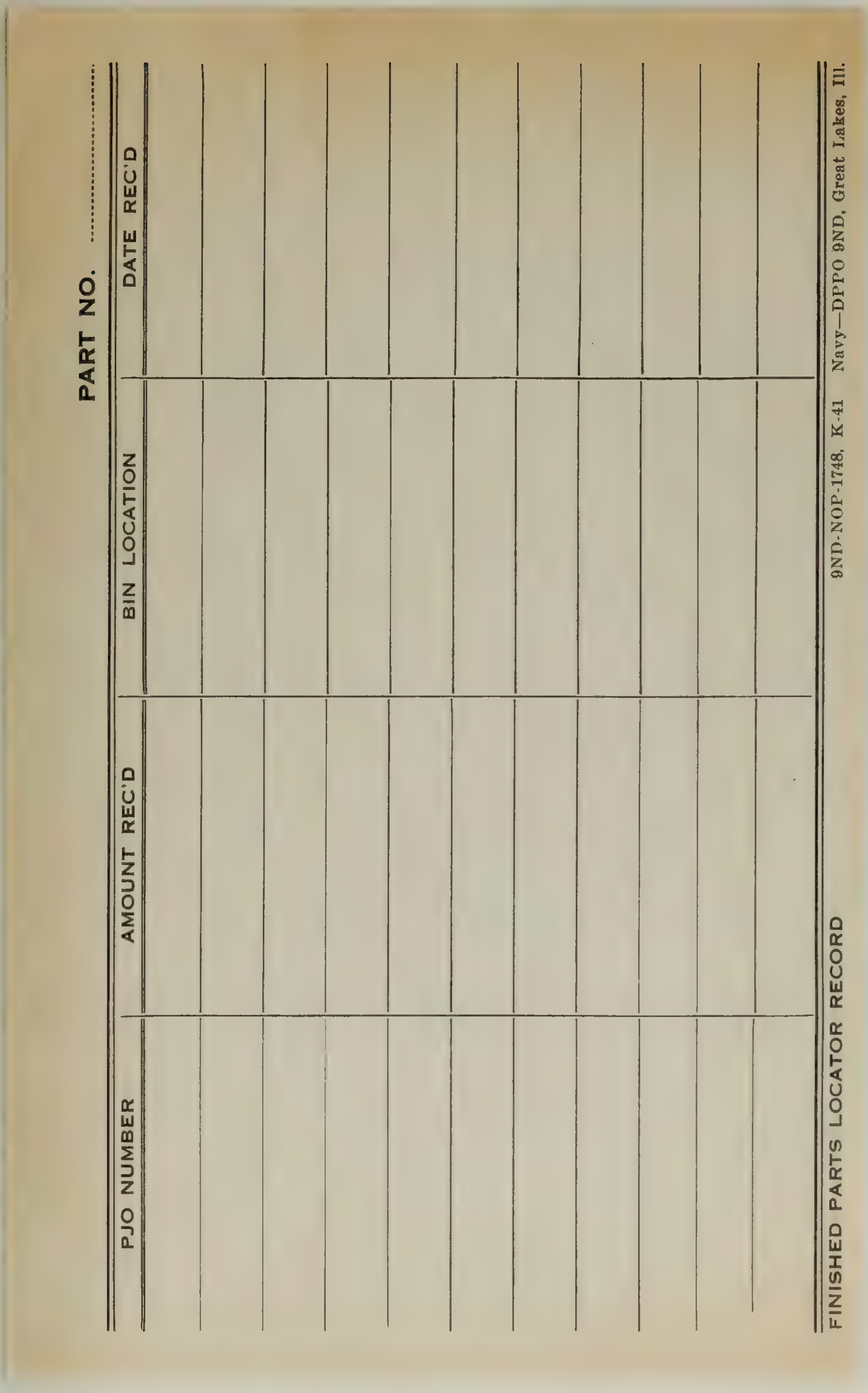
The following diagram shows the flow of information into the Unit, the material originated therein, and the next destination of that material.



The Production Stores Unit

The Production Stores Unit composed of the Finished Parts Stores, Semi-finished Parts Stores, and Raw Material and Casting Stores is charged with the responsibility of receiving, storing, and issuing all production material in process of manufacturing. This material includes raw stock, purchased parts, and manufactured parts, either semi-finished or finished.

Purchased parts or raw material coming into the Unit from the Supply Department are accompanied by a copy of a Stub Requisition. Material or parts manufactured in the plant are accompanied by the Yellow Shop Order Master Card from the Shop Order Kit. All incoming material or parts are identified as to the project number to which they apply, the part number, the Stub number or Shop Order number, depending on how received, and the quantity received. The material or parts are then stored in the area allocated for that particular project or as dictated by the form of the material (such as raw material in big sheets). Information is taken from the Stub Requisition and the Shop Order Master Card to record the location of the material on the Finished Parts Locator Record, Figure 22, and to act as additional information for the cross-reference file. This information is also used to make the appropriate entries on the Commitment and Stores Record Card, Figure 23. This record acts as the balance of stores ledger used in a large number of business concerns. The cross-reference file spoken of is maintained in order to facilitate the shifting of material or parts from one project to another when applicable. However, such shifting must be cleared by the Expediting Unit prior to the shift. The Finished Parts Locator Record mentioned above is used as a means of quickly locating any part

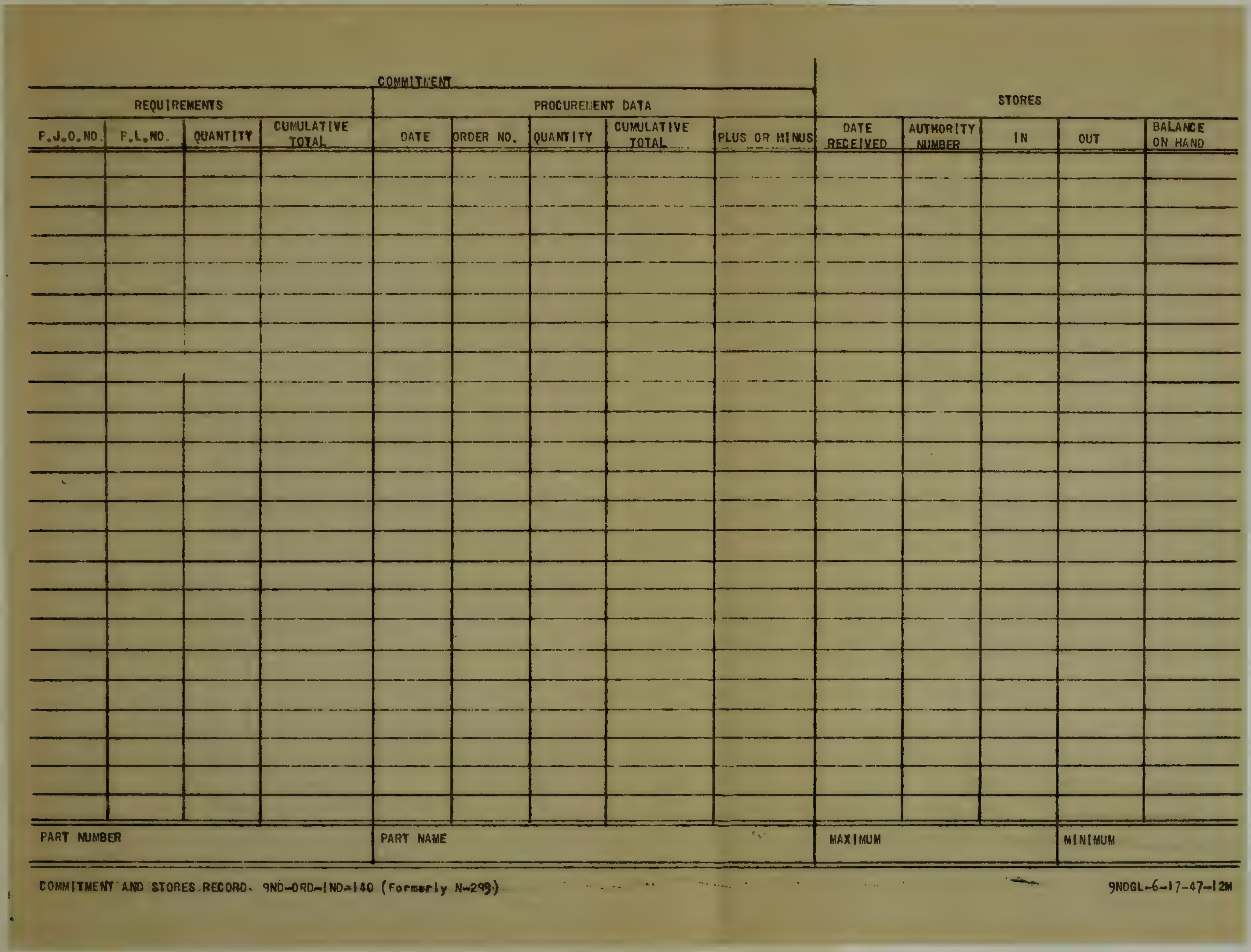


PART NO. ....

PJO NUMBER	AMOUNT REC'D	BIN LOCATION	DATE REC'D

FINISHED PARTS LOCATOR RECORD   9ND-NOP-1748, K-41   Navy—DPPO 9ND, Great Lakes, Ill.

Fig. 22 Finished Parts Locator Record



COMMITMENT									STORES					
REQUIREMENTS				PROCUREMENT DATA										
P.J.O. NO.	P.L. NO.	QUANTITY	CUMULATIVE TOTAL	DATE	ORDER NO.	QUANTITY	CUMULATIVE TOTAL	PLUS OR MINUS	DATE RECEIVED	AUTHORITY NUMBER	IN	OUT	BALANCE ON HAND

PART NUMBER

PART NAME

MAXIMUM

MINIMUM

COMMITMENT AND STORES RECORD. 9ND-ORD-IND-140 (Formerly N-299) 9NDGL-6-17-47-12M

Fig. 23 Commitment and Stores Record Card

stored in the Unit.

The majority of the issuing of parts and material is done on authority of the green Shop Order Master Card and the transaction is conducted in the reverse order as explained for incoming parts or material.

RECOMMENDED PRODUCTION CONTROL PROCEDURE FOR POSSIBLE USE IN NAVAL SHORE ESTABLISHMENTS

Definition of Production Control

Production Control may be defined as "the mental and physical techniques and procedures employed to the end that the right quantity and quality of a product shall be produced at the right time by the best and cheapest methods."[1]

Functions of Production Control

The above definition appears in literature on the subject of production control; its interpretation, however, has extremely broad scope. One interpretation includes as a function of production control such services as the determination of the methods of manufacture, of the required tools of manufacture, and of the operation times involved in the manufacturing process. These functions may be omitted in another interpretation, which might include the determination of the routing and scheduling of the various parts through the plant, and of dispatching the work to the manufacturing divisions.

For the purpose of this paper, the interpretation placed on the definition of production control is based upon the collective opinions expressed in the first six texts in the Bibliography. The authors of these texts are in agreement on the first four functions listed below. The fifth function, the establishment of the labor requirements of a plant, is not discussed at length in the literature on production control. Current investigations of this function relative to a production

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[1] Bethel, Lawrence L.; Tann, Walter L.; Atwater, Franklin S.; Rung, Edward E.; Production Control, McGraw-Hill Company, Incorporated, 1948, pp. 2.

control procedure, and the advantageous results in existing production control departments which include this function, indicate a growing need for the inclusion of this function in a production control procedure to better serve the needs of the production departments. The recommended production control procedure includes the following functions:

a. Establishment of the required quantity and quality of material at the required time and place;

b. Establishment of the specific point-to-point travel of the product as it moves through the plant;

c. Establishment of the specific calendar time for a given job to be in a given stage of manufacture;

d. Establishment of the procedure for releasing orders to the manufacturing divisions, and of maintaining the necessary progress records of the work;

e. Establishment of the labor requirements of the plant.

Application of Production Control Procedure to the Various Plants

No production control procedure, however broad and general in concept, can be formulated to meet the individual needs of a large variety of plants. It is possible, however, to present the general functions of a production control procedure and to study these functions from the point of view of a specific plant's particular needs.

A Naval Shore Establishment may examine its peacetime operations and find that one or more of the listed functions are not applicable to its requirements. On the other hand, in the event of a national emergency when its operations may be vastly expanded, its peacetime production control procedures may not prove adequate. Thus an examination

of the functions of a production control procedure would prove advantageous to a Naval Shore Establishment for planning purposes for plant expansion in times of national emergency.

A production control procedure is greatly influenced by a plant's type of manufacture. The three general types of manufacture carried on in Naval Shore Establishments can be illustrated by the following examples:

a. A Navy Yard Capital ship overhaul activity may replace a boiler for one ship, and exchange the next ship's main batteries. This type of work is sometimes referred to as the job-shop type of manufacture, the manufacture of non-repetitive vastly dissimilar products.

b. An aviation engine overhaul facility may process a variety of engines in small quantities through its shops. This type of work is sometimes referred to as the intermittent type of manufacture, the production of a variety of similar products in lots of limited size.

c. An ordnance plant may produce one item, a forty-millimeter gun, in volumes reaching the capacity of the plant. This type of work is sometimes referred to as the continuous, or mass-production type of manufacture, the production of a few similar products in large volumes.

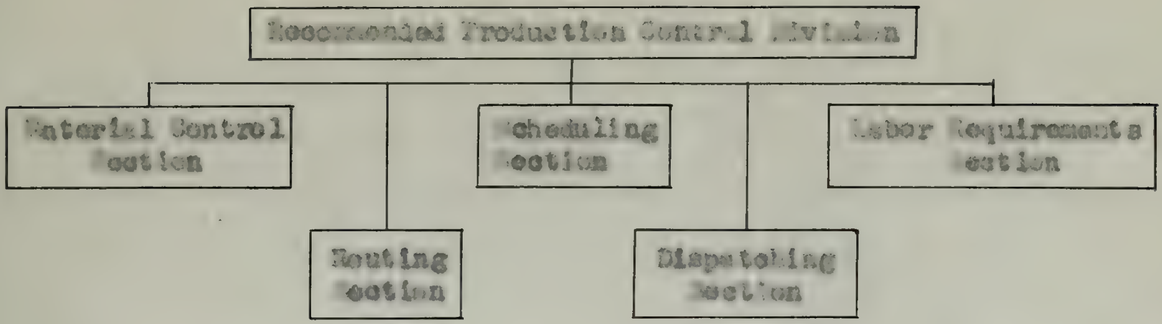
It is obvious that a production control procedure must be tailored to fit the type of a plant's manufacture. In the following discussion of the recommended production control procedure, specific mention is made of the modifications necessary when a function is affected by a plant's type of manufacture.

Another factor relating to a plant's production control procedure is the personalities of the employees. One man may be content to perform a routine type job year in and year out, while another may demand a more stimulating type of work which makes a full demand on his capabilities. A production control procedure must be geared to the individual differences of a plant's staff members.

The factor of cost must be considered in the selection of a production control procedure. The number of people employed in a production control division will influence the cost of the product. The number of employees required depends upon the services required of the production control procedure, the man-hour load these services require, and the ability of the available personnel. Continuous intelligent effort must be made to justify the cost of the services rendered by a production control division. The firm goal of every production control division should be a reduction of its costs and an improvement in its efficiency and in the standard of services rendered to the production division.

Recommended Production Control Procedure

In accordance with this paper's interpretation of the definition of production control, the recommended procedure includes the functions of the following sections: Material Control, Routing, Scheduling, Dispatching, and Labor Requirements. The following chart shows the functional organization of the recommended production control procedure:



The functions of each of these sections are discussed below.

The Recommended Material Control Section. The recommended Material Control Section would be responsible for providing the required quantity and quality of material at the required time and place. The functions of the Section may be listed as follows:

1. Determination of the required quantity of each component part
2. Requisitioning of required materials on the date desired
3. Maintenance of suitable material records

The quantity of each component part is determined by the Material Control Unit of the Naval Ordnance Plant, Indianapolis, from information contained in the Parts List, the Prints, and the Cost Estimating and Scheduling Form. The Unit estimates scrap and losses and issues the Production Breakdown Sheet, the authority to manufacture a specific quantity of a component part. This procedure is recommended for use in Naval Shore Establishments such as Navy Yards and aviation engine overhaul activities. Establishments engaged in mass production, such as an ordnance plant producing solely forty-millimeter guns, may modify the above procedure in view of the fact that the initial determination of the required quantity of a component part will not change without a major alteration in the production facilities or in the product. Thus, while the procedure for determining the quantity of a

component part must be followed once, this function is not a recurring one in the forty-millimeter ordnance plant as it is in a Navy Yard or aviation engine overhaul activity.

The Material Control Unit requisitions the required materials for the required delivery date by issuing a Stub Requisition to the Supply Department. The Stub Requisition may cover either materials in the Supply catalogues, or materials to be purchased from civilian sources. The Unit accomplishes the screening of the available materials in the Supply Department by the use of the Firm Requirement and Obligation of Material Form. This procedure is recommended for all Naval Shore Establishments, with special attention being given to the close cooperation between this function and the Supply Department. The time element between the requisitioning and the receipt of the materials is a vital factor in every industrial activity. It should be the goal of both the Material Control Section, in its function of requisitioning the required materials for the required delivery date, and of the Supply Department to reduce this time element to a minimum consistent with economic factors.

The Material Control Unit is supplied with all Supply catalogues, which inform the Unit of the standard stock items available from the Supply Department. It is the opinion of the author that this informational data must be readily accessible to the Material Control Section of every Naval Shore Establishment.

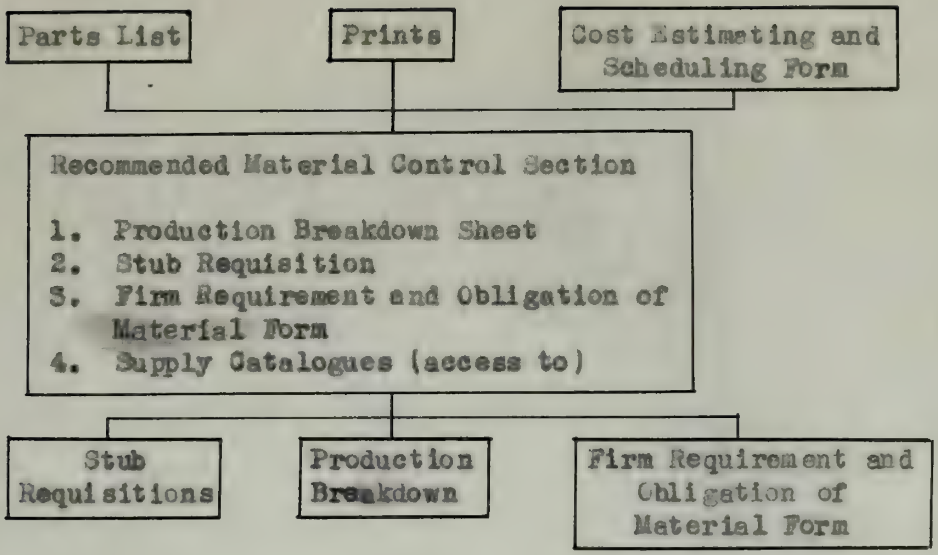
The following diagram shows the information that may be received by, formulated in, and sent from the recommended Material Control Section.

component part must be followed up, this function is not a recurring one in the fertilizer-utilization industries plant as it is in a Navy Yard or aviation engine overhaul activity.

The Material Control Unit requisitions the required materials for the required delivery date by issuing a Stock Requisition to the Supply Department. The Stock Requisition may cover either materials in the Supply catalogues, or materials to be purchased from outside sources. The Unit investigates the quantity of the available materials in the Supply Department by the use of the Stock Requirement and Obligation of Material form. This procedure is recommended for all local demand determinations, with special attention being given to the close cooperation between this function and the Supply Department. The time element between the requisitioning and the receipt of the materials is a vital factor in every industrial activity. It should be the goal of both the Material Control Section, in its function of requisitioning the required materials for the required delivery date, and of the Supply Department to reduce this time element to a minimum consistent with accurate procedures.

The Material Control Unit is supplied with all Supply Catalogues, which inform the Unit of the materials stock available from the Supply Department. It is the opinion of the writer that this information should be readily accessible to the Material Control Section of every Naval Shore Establishment.

The following diagram shows the information that may be obtained by, formulated by, and sent from the recommended Material Control Section.


Parts List
Prints
Cost Estimating and Scheduling Form
Recommended Material Control Section
1. Production Breakdown Sheet
2. Stub Requisition
3. Firm Requirement and Obligation of Material Form
4. Supply Catalogues (access to)
Stub Requisitions
Production Breakdown
Firm Requirement and Obligation of Material Form

The Recommended Routing Section. The recommended Routing Section would be responsible for determining the point-to-point movement of the product through the plant, from the raw material stage to the finished product. The Section may also issue forms necessary for the compilation of data for each operation, and furnish pertinent tool information to the Tool Crib. The functions of the Section would be as follows:

1. Determination of the point-to-point movement of the product through the plant
2. Issuing of the forms for required data for each operation
3. Issuing of the forms for the release of tools to the operator

These three functions are performed by the Shop Scheduling Unit of the Naval Ordnance Plant, Indianapolis, by the issuing of the Shop Order Kit, which consists of nine or more colored IBM cards. The routing of the product through the plant is done in terms of Machining and Assembly Units. Thus, a component part may be routed from the Heavy Machining Unit to the Plating, Painting and Heat Treat Unit, then to Light Machining Unit, next to Inspection, and finally to the Production Stores Unit. The routing is based upon the method of loading the shop

which is on a man-hour basis by Machining Units. The reason that the Naval Ordnance Plant, Indianapolis, uses this method of loading is that the available man-hours of labor is the limiting factor in the plant's productive capacity. The Shop Scheduling Unit maintains a load chart in terms of man-hours for each Machining Unit. The purposes of the load chart are to present the current work load of the plant and to indicate where new work may be added. The load chart permits equitable distribution of the work load and indicates over or under usage of a Unit.

When the Shop Order Kit is received by the Head of a Machining Unit, he assigns the job to a specific employee and a specific machine. Thus, there are two types of routing accomplished at the plant, the general routing by Machining and Assembly Units originated by the Shop Schedule Unit, and the designation of the specific employee and machine by the Head of the Machining or Assembly Unit.

In Naval Shore Establishments, such as Navy Yards and aviation engine overhaul activities, whose productive capacity may be limited by the number of employees, the routing procedure used by the Naval Ordnance Plant, Indianapolis, is recommended. In other Establishments whose productive capacities are limited by the equipment available, the routing procedure should be based on the capabilities of the equipment. Thus, a load chart would be maintained in terms of machine hours, and the routing would be accomplished in terms of specific machines. In this way, a component part may be routed through the plant from specific machine to specific machine, based upon the information available from the machine load chart.

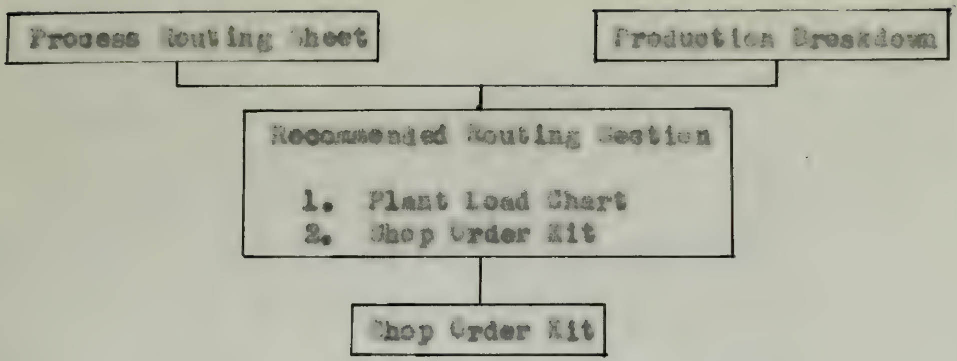
A few Naval Shore Establishments may find that their limiting productive factor fluctuates. There may at times be an excess of machines

and a limited number of employees, and a short time later, this situation might reverse itself, with a higher ceiling on employment, so that the equipment available would become the limiting factor of the activity's capacity. Such a change in the basic principles on which a routing procedure is founded necessitates a flexible procedure capable of being adapted to changing conditions.

The recommended Production Control procedure for an ordnance plant producing solely forty-millimeter guns would not include the function of routing, since the point-to-point movement of the product through the plant is determined during the initial establishment of the production line.

The forms for gathering the data for each operation and for the release of tools to the operator are included in the Shop Order Kit at the Naval Ordnance Plant, Indianapolis. The brown card is used for obtaining the necessary tools; spaces for such data as part identification, quantity, account number, material specification and quantity, satisfactory pieces and rejects, etc., are included on the shop order cards. This procedure is recommended for use in the Routing Sections of Navy Yards and aviation engine overhaul activities. This function is not deemed necessary in a mass-producing ordnance plant.

In the following diagram, the information that may be received by, originated in, and forwarded from the recommended Routing Section is shown.



The Recommended Scheduling Section. The recommended Scheduling Section would be responsible for fitting specific jobs into a general timetable. The Section would determine the calendar dates for the various jobs to conform with the committed delivery date of the finished product.

The functions of the Scheduling Section would be the issuing of the Working Schedule.

The scheduling function is accomplished at the Naval Ordnance Plant, Indianapolis, by the Project Scheduling Unit, the Shop Scheduling Unit, and the Head of a Machining Unit. The Project Scheduling Unit plans the over-all plant schedule in the form of the Forecast of Productive Labor, a chart projecting eighteen months into the future showing the production load in man-hours by divisions. Individual projects are scheduled for completion by months on the Cost Estimating and Scheduling Form. From this form, individual assemblies are scheduled for completion by months on the Internal Schedule Form.

The Shop Scheduling Unit receives the Internal Schedule Form, and from the information contained therein, schedules the completion of component parts by months on the Shop Order Kit. As was discussed previously in the discussion of the recommended Routing Section, the Unit maintains a load chart in terms of man-hours by Machining Units for the purpose of scheduling new work to the Machining Units.

The Head of a Machining Unit receives the Shop Order Kit which has been scheduled for completion by an indicated month. He establishes the sequence of the Shop Order Kits in a way best suited to meet the committed completion dates, and issues the Shop Order Kits to the machine operators in this sequence.

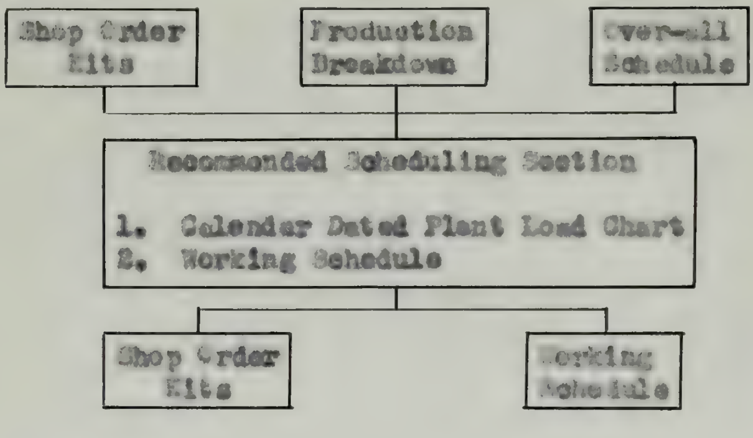
The above scheduling procedure includes functions which may involve a Production Planning Division. In those Naval Shore Establishments whose organizational structure combines the functions of Production Planning with those of Production Control, the scheduling procedure outlined above is recommended for use. Other Establishments, who separate the Production Planning functions from the Production Control functions, may consider the over-all schedule accomplished by the Project Schedule Unit as a function of the Production Planning Division. The Internal Schedule of the Project Scheduling Unit, the completion dates indicated on the Shop Order Kits as accomplished by the Shop Scheduling Unit, and the arrangement of the sequence of the Shop Order Kits as done by the Head of a Machining Unit, may be considered functions of the Production Control Division. For the purpose of this paper, these functions of the Production Control Division would be accomplished by the issuance of the Working Schedule.

The remarks in the recommended Routing Section discussion concerning the type of loading employed in a plant also apply to the recommended Scheduling Section, since these two sections are closely related. The recommended Scheduling Section would maintain a suitable plant load chart similar to that used by the Routing Section. The Scheduling Section's load chart, however, has calendar dates, whereas the Routing Section's load chart has only periods of time. Thus, in a given period

of time, the jobs for a particular work station would be determined by the Routing Section, but the priority of the jobs and the sequence in which they are to be accomplished by the work station are determined by the Scheduling Section. This data is transmitted to the shop in the form of a Working Schedule.

For use in an ordnance plant producing solely forty-millimeter guns, the functions of scheduling is accomplished in the initial establishment of the production line, since the machine rates are set for the desired production rate.

The diagram below shows the information that may be received by, originated by, and sent from the recommended Scheduling Section.



The Recommended Dispatching Section. The recommended Dispatching Section would be the action element of the Production Control Division, and the means by which authority is released to the shop for the accomplishment of the routed and scheduled operations.

The functions of the recommended Dispatching Section may be listed as:

1. Releasing materials and work orders
2. Reporting on the progress of jobs

The function of releasing materials and work orders is accomplished at the Naval Ordnance Plant, Indianapolis, by the Dispatching Unit. The Unit has a series of pocket boards which are arranged by Machining Units and months. When the Unit receives the Shop Order Kit, the green material requisition card is removed from the kit, and the kit placed in the proper pocket. The head of a Machining Unit collects the kits for his unit from the pocket board, arranges the sequence of jobs, and gives a Shop Order Kit to the operator. The operator presents the Shop Order Kit to the Dispatching Unit, receives the material requisition card, draws the material, and begins the job. When the operations scheduled for a Machining Unit are completed, the work piece and the Shop Order Kit are returned to the Dispatching Unit. The Unit then places the Shop Order Kit in the pocket board of the next scheduled Machining Unit. This procedure is repeated until the job is completed, at which time the Shop Order Kit is closed out and the yellow master card returned to the Shop Scheduling Unit. This procedure works well at the Naval Ordnance Plant, Indianapolis, where approximately eighty-five percent of the work on one component part is accomplished by one Machining Unit.

In Naval Shore Establishments whose product must be processed through several shop units, the recommended procedure for the release of the work orders would include some modifications of the Naval Ordnance Plant, Indianapolis, procedure. The recommended procedure would follow the plant procedure until the part is ready for work in the next shop unit. At this time, the next shop unit would be indicated on the Shop Order Kit, and the material handlers would transport the job and Shop Order Kit to the indicated shop unit, notifying the Dispatching Section of the move. This information would permit the Dispatching Section to change the file card of the Shop Order Kit to the proper location in the pocket board. It would also prevent the loss of time, the double material handling, and the congestion of traffic in the vicinity of the Dispatching Section which would result from the use of the Naval Ordnance Plant, Indianapolis, procedure in plants where a component part must be processed several times between various shop groups.

In a Naval Shore Establishment such as an ordnance plant producing solely forty-millimeter guns, the recommended Dispatching Section would not be involved in the daily routine of releasing materials and work orders, since this function would be accomplished when the production line was initially established. The function would be performed only for a change in the product or a change in the equipment of the production line.

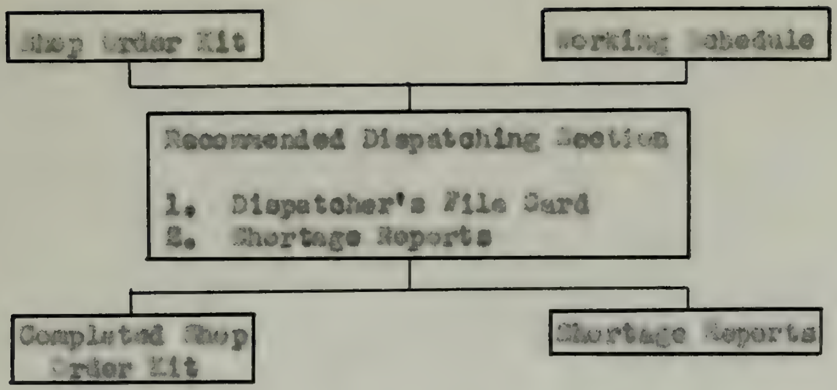
The Dispatching Unit of the Naval Ordnance Plant, Indianapolis, records and reports the progress of jobs on the Dispatcher's File Card. This is the white card of the Shop Order Kit. When the Shop Order Kit is removed from the pocket board in the Dispatching Unit, the Dispatcher's File Card remains in the pocket board to indicate the location of the job.

In addition, the Unit makes a daily floor check of the shop, recording the progress of each job. This information is transferred to the Dispatcher's File Card. Thus, the Dispatching Unit maintains a current status record of the various jobs in the shop. The procedure at the Naval Ordnance Plant, Indianapolis, also includes the recording of the reasons for which a job is being held up. These reasons may include a shortage of tools or a machine breakdown. The shortage of materials is prevented from occurring prior to this stage of processing by another activity.

The recommended Dispatching Section for Navy Yards and activities such as an aviation engine overhaul shop would follow the Naval Ordnance Plant, Indianapolis, procedure for recording and reporting the progress of jobs. The inclusion of certain difficulties such as material and tool shortages, and machine failure may or may not be included in the performance of this function, depending upon the method of handling these problems in the individual Establishments.

In an ordnance plant producing solely forty-millimeter guns, the recommended Dispatching Section would entail only the recording and reporting of the daily production for the purposes of determining if the established rates of production were being maintained.

In the following diagram, the information that may be received by, originated in, and forwarded from the recommended Dispatching Section is shown.



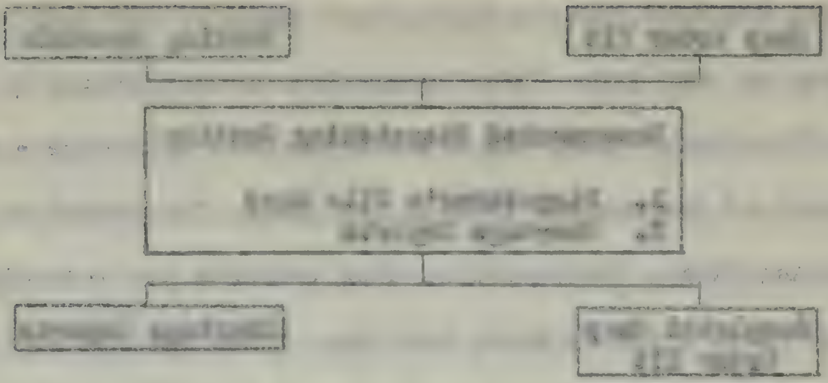
The Recommended Labor Requirements Section. The recommended Labor Requirements Section would be responsible for the determination of the plant's productive labor requirements.

The functions of the Section may be listed as:

1. The determination of inter-divisional labor transfers.
2. The determination of adjustments in the Plant's labor force.

These two functions are accomplished by the Project Scheduling Unit at the Naval Ordnance Plant, Indianapolis. The Unit prepares the Forecast of Productive Labor Chart which is an over-all plant schedule in man-hours extending eighteen months in the future. By comparing the available man-hours of labor with the requirements in man-hours of labor as indicated by the chart, the Unit recommends either an inter-divisional transfer of employees, or an adjustment of the plant's labor force, or both. The recommendations are in the form of a letter, the Monthly Man Load Summary, which is submitted through the Head of the Production Control Division to higher authority for action.

In Navy Yards and aviation engine overhaul activities where the plant may be loaded on the man-hour basis, the above procedure is recommended. In Establishments whose labor requirements are subject to extreme fluctuations, a refinement in the Naval Ordnance Plant,



The Recommended Labor Requirements Activity. The recommended labor-requirements Section would be responsible for the determination of the plant's productive labor requirements.

The functions of the section may be listed as:

1. The determination of inter-divisional labor transfers.
2. The determination of adjustments in the plant's labor force.

These two functions are accomplished by the Project Scheduling Unit at the Naval Ordnance Plant, Indianapolis. The Unit prepares the Schedule of Productive Labor Hours which is an over-all plant schedule in man-hours extending eighteen months in the future. By comparing the available man-hours of labor with the requirements in man-hours of labor as indicated by the charts, the Unit recommends either an inter-divisional transfer of employees, or an adjustment of the plant's labor force, or both. The recommendations are in the form of a letter, the Monthly Man Load Summary, which is submitted through the Head of the Production Control Division to higher authority for action.

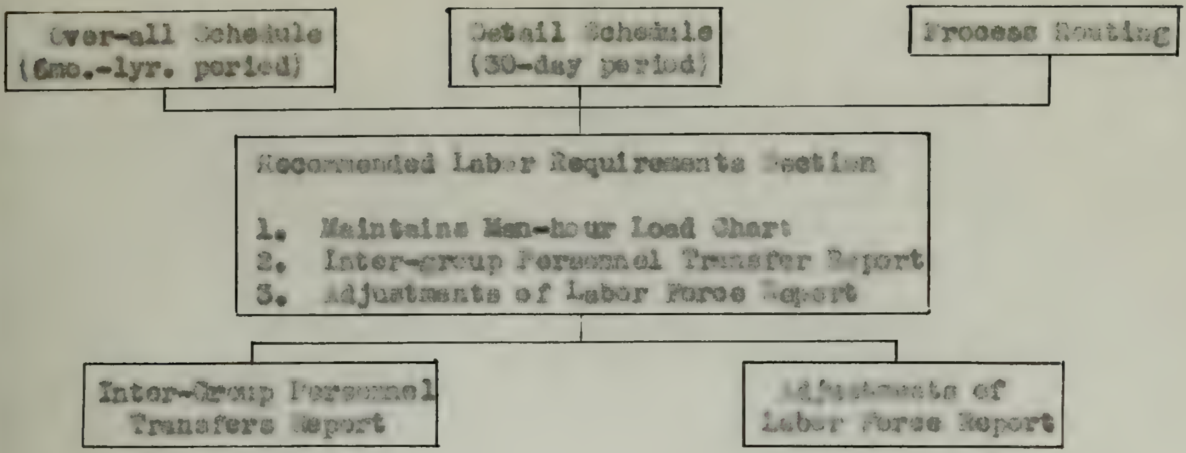
In Navy Yards and aviation engine overhaul activities where the plant may be loaded on the one-hour basis, the above procedure is recommended. In installations where labor requirements are subject to extreme fluctuations, a refinement in the Naval Ordnance Plant.

Indianapolis, procedure may prove beneficial. This would be the maintenance of a man-hour load chart by job classification. The factor of cost of staff personnel to maintain such a detailed chart must be weighed by each individual activity against the advantages such a chart might afford.

In Navy Yards and aviation engine overhaul activities where the plant is loaded on a machine-hour basis, the recommended Labor Requirements Section would maintain a man-hour load chart for the various machining groups. From the information available from the chart, the Section would recommend the inter-group transfer of personnel and the adjustment of the activity's labor force.

In an ordnance plant producing solely forty-millimeter guns, the recommended Labor Requirements Section would not be involved in the extensive procedures outlined above. Normally, the labor requirements of a production line are relatively constant. In some cases, however, when the line is operating at a reduced production rate, the Section would determine and recommend to higher authority the labor requirements for partial operation, such as one-half or three-quarters of the full production rate. It would not be necessary for the Section to maintain a man-hour load chart.

The following diagram shows the information that may be received by, originated in, and sent from the recommended Labor Requirements Section.


Over-all Schedule
(6mo.-1yr. period)
Detail Schedule
(30-day period)
Process Routing
Recommended Labor Requirements Section
1. Maintains Man-hour Load Chart
2. Inter-group Personnel Transfer Report
3. Adjustments of Labor Force Report
Inter-Group Personnel
Transfers Report
Adjustments of
Labor Force Report

CONCLUSIONS

The production control procedure used at the Naval Ordnance Plant, Indianapolis, Indiana, may be adapted with modifications for use in other Naval Shore Establishments. The procedure used accomplishes the functions of material control, routing, scheduling, dispatching, and the determination of labor requirements.

The production control procedure recommended for use in Navy Yards, aviation engine overhaul activities, and similar activities is summarized below:

1. The recommended Material Control Section would function along the general lines of that at NOPI.
2. The recommended Routing Section would function as does NOPI's for those Establishments whose productive capacity is limited by a personnel ceiling. In other Establishments where available equipment is the limiting factor in productive capacity, the recommended Routing Section would base its operations on the available machine capacity.
3. The recommended Scheduling Section would be based on principles similar to those for the recommended Routing Section. Some Establishments may delegate the responsibility of preparing the over-all schedule to a Production Planning Division, leaving the responsibility of preparing the detailed schedule to the Production Control Division.
4. The recommended Dispatching Section would operate in a manner similar to the procedure used at NOPI, with the possible modification of changing the flow of work between

machining groups.

5. The recommended Labor Requirements Section would be patterned after NOPI's, with the possible modification of including the element of job classification in the man load chart.

The production control procedure recommended for use in an ordnance plant producing solely forty-millimeter guns and similar mass-producing Naval Shore Establishments is summarized below:

1. The recommended Material Control Section would perform the functions of the Section for the initial establishment of the production line, and for major changes in equipment and product. Otherwise, the Section would not be involved in day-to-day procedure used at NOPI.
2. The Establishments would not need Routing and Scheduling Sections, since the functions of these sections are fulfilled in the establishment of the production line.
3. The recommended Dispatching Section would involve only a simplified procedure of recording and reporting the daily production.
4. The recommended Labor Requirements Section would perform the functions of the Section for the initial establishment of the production line, and for major changes in equipment and product. Otherwise, the Section would not be involved in the day-to-day procedure used at NOPI.

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Production control procecure for possible use in Naval Shore Estab-
lishments based upon a study of the production control division at the Naval Ordnance Plant, Indianapolis.

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